

FISHERY DATA SERIES NO. 90-41

STOCK ASSESSMENT
OF DOLLY VARDEN IN THE
BUSKIN RIVER, KODIAK, ALASKA 1989¹

By

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ABSTRACT

A creel survey was conducted 22 April through 26 May 1989 to estimate sport effort for and harvest of Dolly Varden *Salvelinus malma* in the Buskin River. Sport anglers fished an estimated 5,204 angler-hours and harvested (kept) an estimated 5,761 Dolly Varden. In addition, an estimated 5,567 Dolly Varden were caught and released. The migrations of Dolly Varden greater than 300 millimeters (fork length) in the Buskin River were monitored through a weir operated from 27 April through 7 October 1989. A total of 35,605 emigrant and 30,851 immigrant Dolly Varden were counted through the weir.

Two sample Petersen population estimates of Dolly Varden in the Buskin and American rivers during October of 1989 resulted in estimates of 100,430 Dolly Varden in the Buskin River, 4,125 in the American River.

KEY WORDS: Dolly Varden, *Salvelinus malma*, coho salmon, *Oncorhynchus kisutch*, effort, harvest, size, age, escapement, Buskin River, American River, Olds River, Kodiak, Alaska.

INTRODUCTION

The Buskin River (Figure 1) is centrally located in the urban area of Kodiak Island, Alaska, and receives more fishing effort by anglers than any other water on Kodiak Island. The river contains steelhead and rainbow trout *Oncorhynchus mykiss*, Dolly Varden *Salvelinus malma*, and three species of North American Pacific salmon: coho salmon *Oncorhynchus kisutch*, sockeye salmon *O. nerka*, and pink salmon, *O. gorbuscha*. In 1988, approximately 40.0% of the sport harvest (all species) of all Kodiak lakes and streams (Mills 1988) occurred in the Buskin River and approximately 50.0% of the total Kodiak area Dolly Varden harvest occurred in the Buskin River (Mills 1988). The sport fishery is directed at anadromous Dolly Varden during April and May, sockeye salmon and pink salmon during June through mid-August, and coho salmon during mid-August through mid-October. Immigrant Dolly Varden are also caught during mid-summer through fall.

Dolly Varden that overwinter in Buskin Lake are anadromous and migrate during the summer months to marine and freshwater locations throughout Chiniak Bay (Sonnichsen et al. in press). As a result, these fish contribute to fisheries other than the Buskin River fishery. Buskin Lake (101.5 surface ha) is the major Dolly Varden overwintering site for the Chiniak Bay area. Dolly Varden usually commence emigration from Buskin Lake during mid-April and continue through May or early June. However, a late spring break-up and heavy ice cover on Buskin Lake may delay the emigration by 2 weeks in some years. Dolly Varden immigration from salt water begins in July and continues into early winter. The American and Olds rivers are known to be major spawning sites for Dolly Varden that overwinter in Buskin Lake (Sonnichsen et al. in press).

In 1985, the Sport Fish Division of the Alaska Department of Fish and Game (ADFG) initiated a project to estimate the magnitude and composition of the Pacific salmon, Dolly Varden, and steelhead trout returns to the Buskin River (Murray 1986). The project consisted of: (1) counting the escapements through a weir; (2) estimating angler effort and harvest for the spring Dolly Varden fishery; (3) estimating the age, sex, and size composition of Dolly Varden in the sport harvest and the escapement and of coho salmon in the escapement; and (4) identifying migrational patterns and stock structure of Buskin River Dolly Varden through a tagging program.

The objective of this report is to present baseline data for the 1989 Buskin River Dolly Varden sport fishery and the results of Dolly Varden population estimates conducted in the Buskin, American, and Olds rivers in the fall of 1989. Buskin River coho salmon data and Buskin River weir counts of all species are also included.

SPORT FISHERY

Methods

The Buskin River sport fishery for Dolly Varden occurs throughout the spring emigration and the summer-fall immigration. The sport fishery for both emigrant and immigrant fish generally occurs throughout the river (Figure 1).

In 1989, anglers were permitted a daily bag limit of 10 Dolly Varden (no size limit) with a 10 fish possession limit (ADFG 1989).

A creel survey was conducted on the Buskin River from 22 April through 26 May 1989 to estimate sport effort in angler-hours and sport catch (fish kept plus fish released) and harvest (fish kept only) of Dolly Varden. The survey used a stratified random sampling design to conduct counts and interviews of anglers. The survey was stratified into weekday and weekend/holiday strata. Approximately 55% of the sampling effort was allocated to weekdays and 45% to weekend/holidays. For the creel survey, the fishing day was considered to be 15 hours in duration (0700-2200 hours). The fishing day was stratified into three time strata: A, 0700-1159 hours; B, 1200-1659 hours; and C, 1700-2200 hours. Sampling effort was allocated optimally among the three periods in each strata based on the proportional effort estimates for each period in 1987 and 1988 (from Murray 1988 and 1989). Each sampling trip was 2.5 hours in duration.

Counts of anglers were used to estimate angler effort and interviews of completed-trip anglers were used to estimate catch and harvest rates and sample the sport harvest for biological data. During a selected sample period, a starting time was randomly selected to count the number of anglers. Counts were conducted by driving the length of the fishing area as quickly as possible and counting the number of people engaged in fishing. Counts took approximately 20 minutes to complete and were considered instantaneous (Neuhold and Lu 1957).

The remaining time in the sample trip was spent conducting angler interviews. Interviews were collected by monitoring the major access points to the fishery and interviewing anglers as they departed the fishery. Only anglers who had completed fishing were interviewed. The following information was recorded during each interview: number of fish released by species, number of fish retained by species, and total hours fished (to the nearest 1/4 hour). Demographic information about each angler was also recorded.

Angler effort was calculated for each of the weekday and weekend/holiday strata as:

$$\hat{E}_h = D_h H_h \bar{x}_h \quad (1)$$

where:

\hat{E}_h = estimated effort for stratum h ,

D_h = total number of primary units or days in stratum h ,

H_h = number of hours in each sample period in stratum h ,

\bar{x}_h = the mean number of anglers per count in stratum h

$$= \left(\sum_{i=1}^{d_h} x_{hi} \right) / d_h \quad (2)$$

x_{hi} = angler count taken in day i of stratum h , and

d_h = number of days sampled in stratum h .

The variance of this estimate was calculated as:

$$\hat{V}(E_h) = (1-f_{1h}) (D_h H_h)^2 (s_{1h}^2/d_h) \quad (3)$$

where:

f_{1h} = sampling fraction for days (count samples)

$$= d_h/D_h \quad (4)$$

s_{1h}^2 = the among day variance for the effort estimate,

$$= \frac{\sum_{i=1}^{d_h} (x_{hi} - \bar{x}_h)^2}{d_h - 1} \quad (5)$$

Completed-trip angler interviews were used to estimate the catch and harvest rates. The catch per unit effort (CPUE) and harvest per unit effort (HPUE) estimates were obtained by the jackknife estimation approach (Efron 1982). In order to account for unequal sampling rates, each angler's catch and harvest was weighted by the relative numbers of anglers using the fishery during the sample period (as measured from the angler count).

To obtain the estimates of catch and harvest the following procedures were followed. First, the interview data were weighted as noted above:

c'_{hij} = weighted catch for angler j during day i of stratum h

$$= (x_{hi}/\bar{x}_h) c_{hij} \quad (6)$$

where:

c_{hij} = catch of angler j during day i of stratum h .

Then, using the weighted catches, the jackknife sample estimate of mean cpue was obtained as follows:

$CPUE_{hij}^{*}$ = the jackknifed weighted cpue for angler j in day i within stratum h ;

$$= \frac{\sum_{\substack{o=1 \\ o \neq j}}^{m_{hi}} c_{hio}}{\sum_{\substack{o=1 \\ o \neq j}}^{m_{hi}} e_{hio}} ; \quad (7)$$

where:

o = subscript denoting angler interviewed within each sampled day;
and

e_{hio} = unweighted effort in hours expended by angler o within day i and stratum h ;

The jackknife mean cpue for day i within stratum h was then obtained by:

$$\overline{CPUE}_{hi}^{*} = \frac{\sum_{j=1}^{m_{hi}} CPUE_{hij}^{*}}{m_{hi}} . \quad (8)$$

Then the bias correction (adapted from Efron 1982, equation 2.8, page 6) was performed:

$$\overline{CPUE}_{hi}^{*+} = [m_{hi} (\overline{CPUE}_{hi}' - \overline{CPUE}_{hi}^{*})] + [\overline{CPUE}_{hi}^{*}] ; \quad (9)$$

where:

\overline{CPUE}_{hi}' = the standard weighted ratio estimator:

$$= \frac{\sum_{j=1}^{m_{hi}} c_{hij}}{\sum_{j=1}^{m_{hi}} e_{hij}} . \quad (10)$$

The bias-corrected weighted jackknife mean was then averaged over all days sampled within stratum h :

$$\frac{\hat{\Delta}}{\text{CPUE}_h}{}^{*\dagger} = \frac{\sum_{i=1}^{d_h} \frac{\hat{\Delta}}{\text{CPUE}_{hi}}{}^{*\dagger}}{d_h} ; \quad (11)$$

where:

d_h = number of days sampled for interviews within stratum h ;

This estimated mean cpue for each stratum was then used to estimate the catch for the stratum by expansion:

$$\hat{C}_h = E_h \frac{\hat{\Delta}}{\text{CPUE}_h}{}^{*\dagger} ; \quad (12)$$

The harvest estimate for each stratum was calculated by substituting harvest for catch in the above equations.

The variance of the estimated catch for stratum h was obtained by the formula proposed by Goodman (1960) for the variance of a product of independent random variates:

$$\hat{V}[\hat{C}_h] = E_h^2 \hat{V}\left[\frac{\hat{\Delta}}{\text{CPUE}_h}{}^{*\dagger}\right] + \left[\frac{\hat{\Delta}}{\text{CPUE}_h}{}^{*\dagger}\right]^2 \hat{V}[E_h] - \hat{V}\left[\frac{\hat{\Delta}}{\text{CPUE}_h}{}^{*\dagger}\right] \hat{V}[E_h] ; \quad (13)$$

where:

$\hat{V}\left[\frac{\hat{\Delta}}{\text{CPUE}_h}{}^{*\dagger}\right]$ = estimated variance of the estimated mean bias-corrected weighted jackknife cpue for stratum h , obtained by the two-stage variance equation (following the approach outlined by Cochran 1977), omitting the finite population correction (fpc) factor for the second stage units;

$$= (1 - f_{1h}) \frac{s_{1h}^2}{d_h} + f_{1h} \sum_{i=1}^{d_h} \left\{ \frac{s_{2hi}^2}{d_h^2} \right\} ; \quad (14)$$

f_{1h} = sampling fraction for days (interview samples);

$$= \frac{d_h}{D_h} ; \quad (15)$$

s_{1h}^2 = the among day variance for the cpue estimate;

$$= \frac{\sum_{i=1}^{d_h} (\overline{CPUE_{hi}}^* - \overline{CPUE_h}^*)^2}{d_h - 1} ; \quad (16)$$

s_{2hi}^{2*} = jackknife estimate of the variance for the jackknifed daily mean cpue for day i within stratum h (adapted from Efron 1982, equation 3.2, page 13), note that the bias-corrected values for cpue were not used in this calculation as bias-corrected cpue's are not estimable for individual anglers;

$$= \frac{(m_{hi} - 1)}{m_{hi}} \sum_{j=1}^{m_{hi}} (CPUE_{hij}^* - \overline{CPUE_{hi}}^*)^2 ; \quad (17)$$

Variance estimates for the estimated harvest were obtained by substituting harvest for catch in the above equations.

Major assumptions necessary for the creel survey are:

1. angler counts made on consecutive days are independent;
2. no significant fishing effort occurs during the hours 2200-0700;
3. interviewed anglers are representative of the total angler population;
4. catch and harvest are independent of duration of fishing trip (as per DiConstanzo 1956);
5. angler effort, catch, and harvest are normally distributed random variables.

Results

Angler counts (Figure 2, and Appendix A1) on weekend days were generally higher than those from weekdays. Counts were relatively low in the morning, with all the counts of over 30 anglers occurring after 1400 hours (Figure 2). Angler effort on weekends was estimated to be a total of 2,055 hours, and on weekdays 3,149 hours (Table 1 and Appendix A2).

Mean harvest rates per period for the weekend fishery ranged from 1.1479 Dolly Varden per hour in period A to 0.3747 per hour in period C (Table 1). On weekdays, harvest rates ranged from 3.8282 Dolly Varden per hour in period A to 0.9159 per hour in period B (Table 1). Catch rates ranged from 5.8429 per hour during weekends period A to 0.8760 per hour during weekends period C (Table 2).

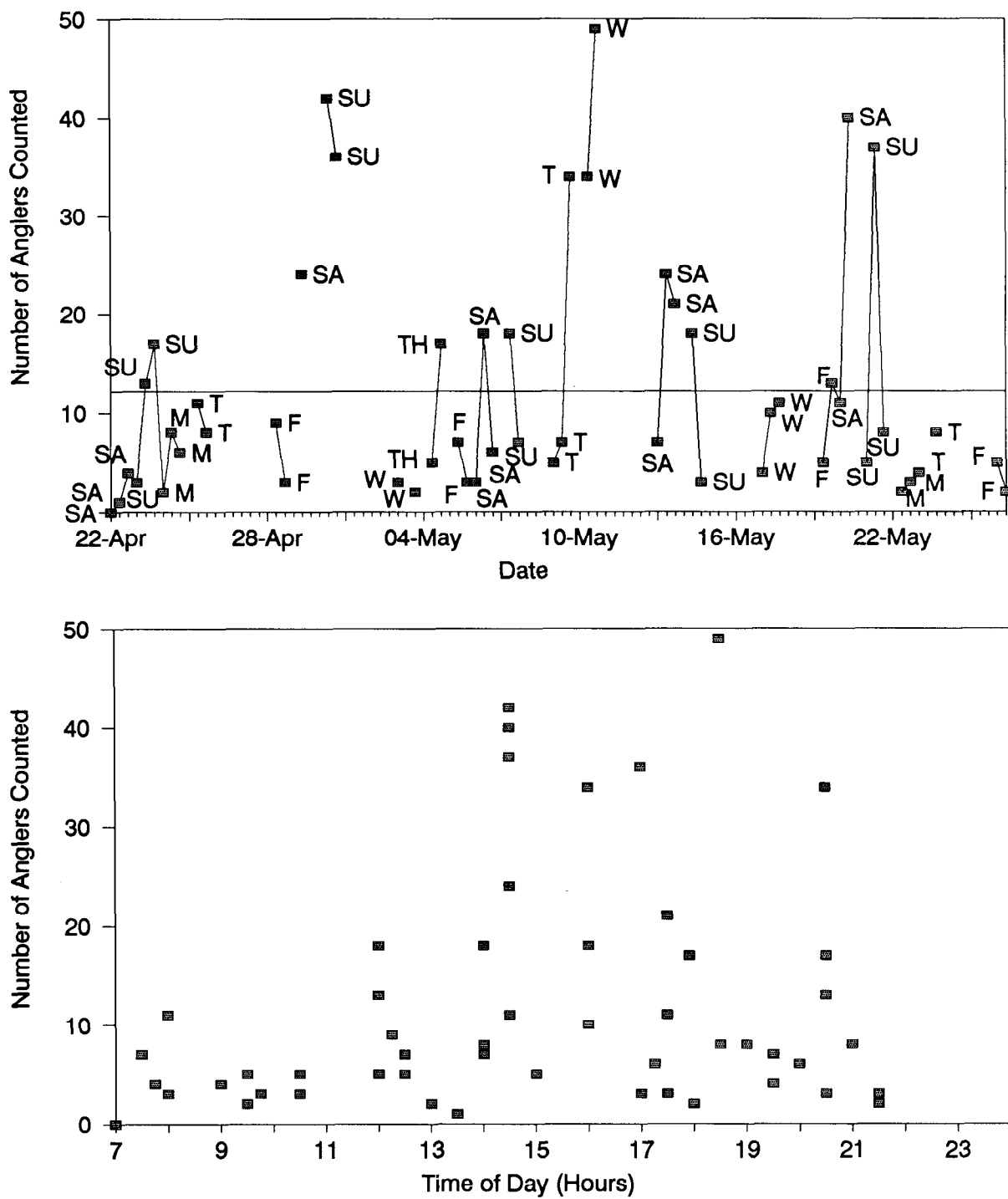


Figure 2. Distribution of angler counts across days (top graph) and across hours with all days combined (bottom graph) in the Buskin River creel survey, 22 April through 26 May, 1989.

Table 1. Estimated effort and harvest of Dolly Varden during the Buskin River sport fishery, 22 April through 26 May, 1989.

Component	Effort (ang-hrs)	Variance Effort	HPUE (fish/hr)	Variance HPUE	Harvest	Variance Harvest	SE Harvest	95% CI	Relative Precision ^a
Weekends									
Period A	242	6,069.0	1.1479	0.2177	278	19,425.1	139.37	5 - 551	98.3%
Period B	1,175	41,792.0	0.5684	0.0286	668	51,792.7	227.58	222 - 1,114	66.8%
Period C	638	40,156.0	0.3747	0.0223	239	13,819.5	117.56	9 - 469	96.4%
Weekdays									
Period A	450	4,063.0	3.8282	3.8096	1,723	815,509.3	903.06	(47) - 3,493	102.7%
Period B	1,170	104,339.0	1.2423	0.3247	1,453	571,630.3	756.06	(29) - 2,935	102.0%
Period C	1,528	239,414.0	0.9159	0.1517	1,400	519,169.3	720.53	(12) - 2,812	100.9%
Totals:									
Weekdays	3,149	347,816			4,576	1,906,309	1,380.7	1,870 - 7,282	59.1%
Weekends	2,055	88,017			1,185	85,037	291.6	613 - 1,757	48.2%
Grand Total:	5,204	435,833			5,761	1,991,346	1,411.2	2,995 - 8,527	48.0%

^a Relative precision of 95% confidence interval.

Table 2. Estimated effort and catch of Dolly Varden during the Buskin River sport fishery, 22 April through 26 May, 1989.

Component	Effort (ang-hrs)	Variance Effort	CPUE (fish/hr)	Variance CPUE	Catch	Variance Catch	SE Catch	Relative 95% CI Precision ^a			
Weekends											
Period A	242	6,069.0	5.8429	5.6461	1,414	503,587.2	709.64	23	-	2,805	98.4%
Period B	1,175	41,792.0	1.8993	0.1470	2,232	347,569.8	589.55	1,076	-	3,388	51.8%
Period C	638	40,156.0	0.8760	0.0076	559	58,661.0	242.20	84	-	1,034	84.9%
Weekdays											
Period A	450	4,063.0	4.5954	4.2429	2,068	927,748.6	963.20	180	-	3,956	91.3%
Period B	1,170	104,339.0	1.7718	0.4187	2,073	857,020.5	925.75	259	-	3,887	87.5%
Period C	1,529	239,414.0	1.9506	0.6211	2,982	2,214,265.1	1,488.04	65	-	5,899	97.8%
Totals:											
Weekdays	3,149	347,816			7,123	3,999,034	1,999.8	3,203	-	11,043	55.0%
Weekends	2,055	88,017			4,205	909,818	953.8	2,335	-	6,075	44.5%
Grand Total:	5,204	435,833			11,328	4,908,852	2,215.6	6,985	-	15,671	38.3%

^a Relative precision of 95% confidence interval.

An estimated 11,328 Dolly Varden were caught from 22 April through 26 May (Table 2). Only 5,761 Dolly Varden, or 51% of the total catch, were harvested (Table 1). Most of the harvest occurred during the weekday fishery (4,576 fish or 83%).

Many of the Dolly Varden harvested in the Buskin River are small. Fifty-two percent of the random sample of fish taken in the harvest were less than 300 mm fork length (Figure 3).

A comparison of relative precision¹ for the estimates of harvest and catch (Tables 1 and 2) shows that weekday estimates were slightly less precise than weekends. The high degree of variability is attributed to the sporadic nature of the Dolly Varden fishery; no consistent pattern was obvious for fishing effort (Figure 2).

In all strata, most anglers interviewed were local and many were members of the military (Table 3).

BUSKIN MIGRATIONS

Methods

Fish Counts:

The Buskin River weir was located 2 km upstream of the river mouth at an area approximately 40 m wide. Both river banks at the weir site are steep and the river bottom is predominantly small rock substrate. The weir is constructed of 21 mm diameter aluminum pipe spaced 21 mm apart. Adult fish counted through the weir gates were identified by species and the daily totals recorded. The weir reliably stops only those fish greater than 300 mm fork length, although some smaller Dolly Varden were captured for biological sampling and tagging by using a seine upstream of the weir. Roughly 25% of the Dolly Varden emigrating past the weir each day were examined for tags and roughly 10% were tagged with Floy tags and also given adipose clips.

Biological Data:

During emigration, a random sample of Dolly Varden captured in the seine upstream of the weir were sampled for size data each week. Sampled fish were measured for tip-of-snout to fork-of-tail length to the nearest millimeter. Otoliths were collected from a sample of Dolly Varden for age analysis. Otoliths were placed in a black watch glass filled with water and read with a binocular microscope (10X) using reflected light.

During immigration, a sample of coho salmon captured at the weir were measured for mid-eye to fork-of-tail length. Three scales were taken for aging from the preferred area (Clutter and Whitesel 1956) of each sampled coho salmon. These scales were mounted on a gummed card. The cards were

¹ Relative precision of 95% confidence interval = $(1.96SE/estimate)$.

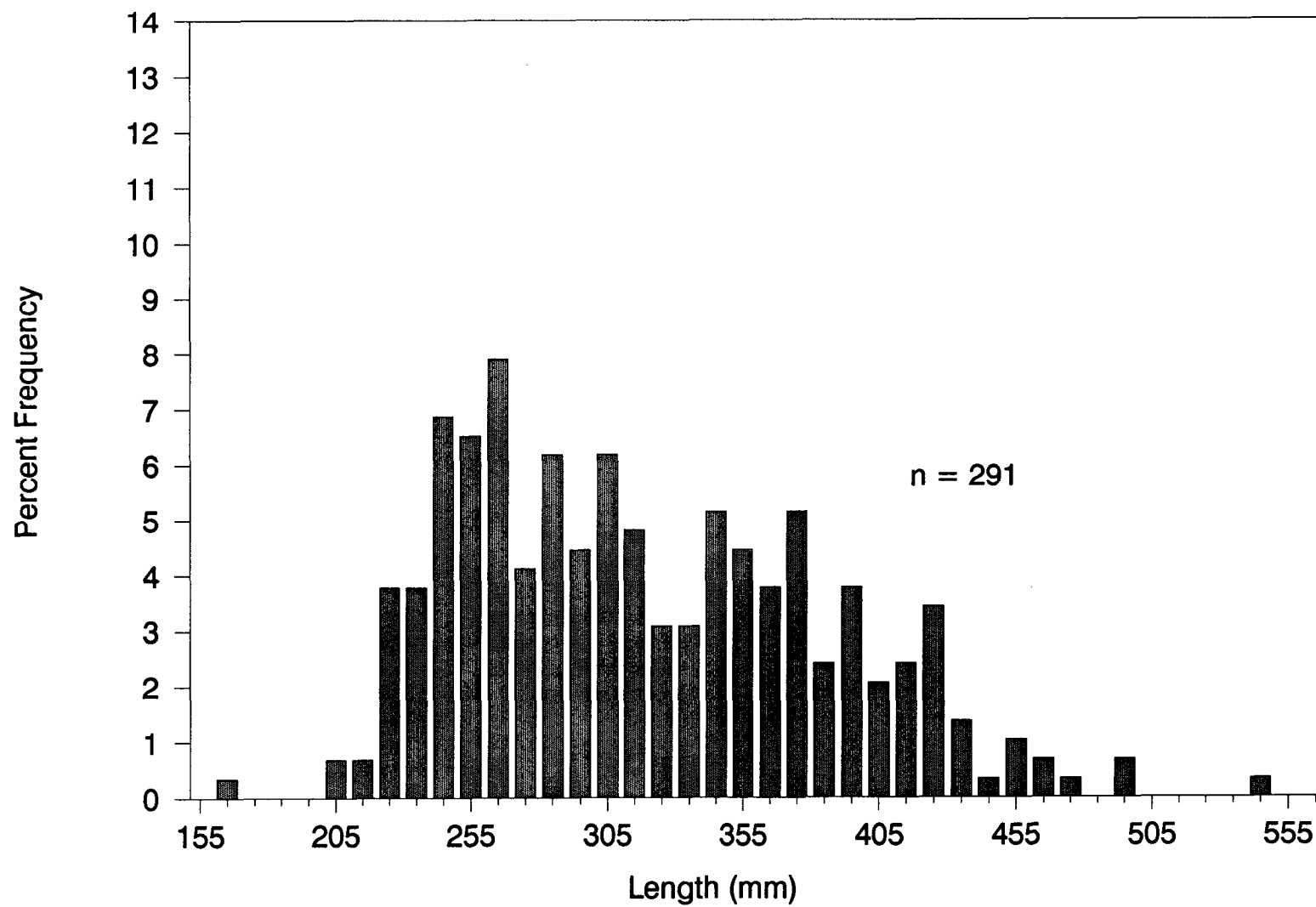


Figure 3. Length frequency of Dolly Varden sampled from the Buskin River sport harvest, May 1989.

Table 3. Demographic information from interviewed anglers during each strata of the 1989 Buskin River creel survey.

Stratum	Local/Nonlocal			Tourist/Military ^a			Alaska Resident		
	Local	Nonlocal	Blank	Tourist	Military	Blank	Resident	Nonres.	Blank
Weekends Period A	29	0	0	0	19	10	19	10	0
Weekends Period B	76	5	8	0	44	45	80	9	0
Weekends Period C	58	0	0	0	24	34	52	6	0
Weekdays Period A	14	0	1	0	4	11	12	2	1
Weekdays Period B	80	4	1	3	42	40	69	15	1
Weekdays Period C	135	5	1	2	92	47	113	27	1

^a An angler could be recorded as a tourist or a member of the military, but not both.

thermohydraulically pressed against acetate cards, and the resulting impressions were displayed on a microfiche projector for age determination.

The proportional age composition of emigrating Dolly Varden captured by seine and coho salmon in the escapement were estimated. Letting \hat{p}_h equal the estimated proportion of age class h, the variance of \hat{p}_h was estimated as:

$$V[\hat{p}_h] = \hat{p}_h(1 - \hat{p}_h)/(n_t - 1), \quad (18)$$

where n_t is the number of otoliths or scale samples read.

Results

Fish Counts:

The Dolly Varden count through Buskin River weir from 27 April through 9 October 1989 totaled 35,605 emigrant and 30,851 immigrant Dolly Varden (Appendix A3). The peak of Dolly Varden emigration (Figure 4) took place from 9 May through 20 May, nearly 2 weeks after the weir was made operable. A few Dolly Varden probably emigrated before the weir was in place, but these were probably only a minor component of the total emigration.

Although peak immigration occurred well before the weir was removed on 9 October (Figure 4), significant numbers of Dolly Varden, especially those that were spawning in other locations, that probably immigrated to the system after the weir was removed. Therefore, the count of immigrating Dolly Varden is not complete.

A total of 165 emigrant steelhead and 65 immigrant steelhead were counted at the weir. The largest number of immigrating salmon were pink salmon with 158,721 counted, followed by 17,820 sockeye salmon and 9,531 coho salmon (Appendix A3).

Biological Data:

The K-sample Anderson-Darling test comparing lengths of Dolly Varden captured in a seine in the area immediately upstream of the Buskin River weir during each week of May 1989 indicated significant differences among the four weeks (with $A^2_{akN} = 55.05$, $\sigma_N = 1.7204$, and $T_{akN} = 39.687$, with the critical value of 1.89 for T_{akN}). Comparisons between individual weeks were all significant except between 7 May and 10 May (Table 4). Mean lengths decreased as the emigration progressed (Table 5), indicating that the larger fish leave earlier in the emigration. The reduction in length is most obvious when the sample from 7 May is compared with the sample from 27 May (Figure 5). It is important to note that these length samples were taken with a seine in front of the weir. Fish counted through the weir tended to be larger (Figure 6). The weir count includes fish less than 300 mm that were caught in the seine and any that were counted through the weir, but is incomplete for this size class because many more could have passed unseen through the pickets of the weir.

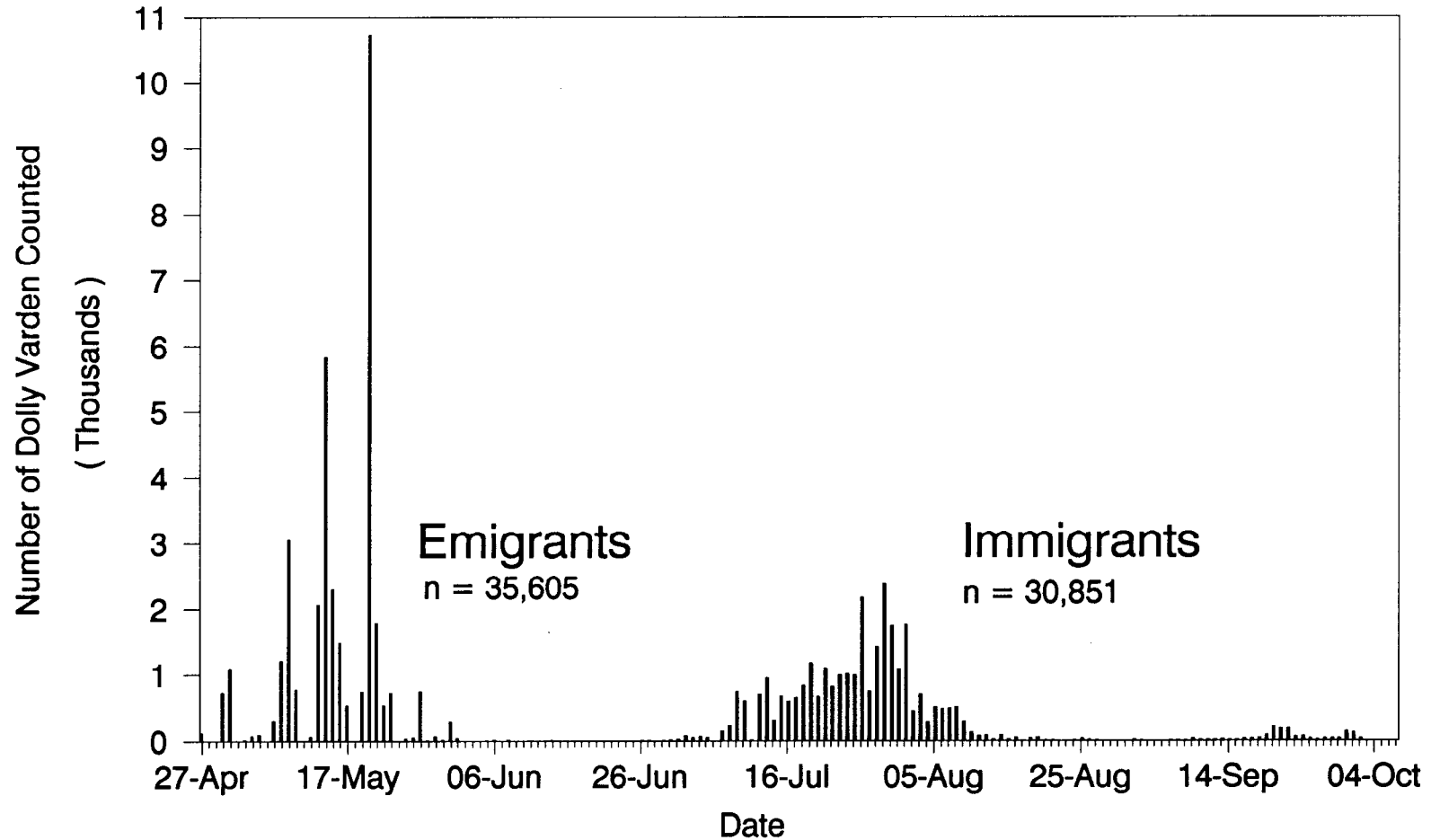


Figure 4. Daily counts of Dolly Varden at the Buskin River weir, 1989. The emigration counts include small fish (< 300 mm) captured with a seine in the area immediately upstream of the weir.

Table 4. T_{akN} values from Anderson-Darling tests comparing lengths of emigrating Dolly Varden sampled with a seine at the Buskin River weir in spring 1989.^a

Date	T_{akN} ^b			
	7 May	10 May	16 May	27 May
7 May	---			
10 May	-0.528	---		
16 May	15.319*	14.207*	---	
27 May	42.478*	39.228*	17.124*	---

^a An * indicates a significant difference in size distributions at $\alpha = 0.05$.

^b Overall $T_{akN} = 39.687$.

Table 5. Lengths of Dolly Varden captured with a seine at the Buskin River weir, May 1989.

Date	Sample Size	Length (mm)			
		Mean	SE	Minimum	Maximum
07 May 1989	130	364	5	80	588
10 May 1989	130	365	5	235	516
16 May 1989	139	334	5	205	482
27 May 1989	140	300	6	183	538

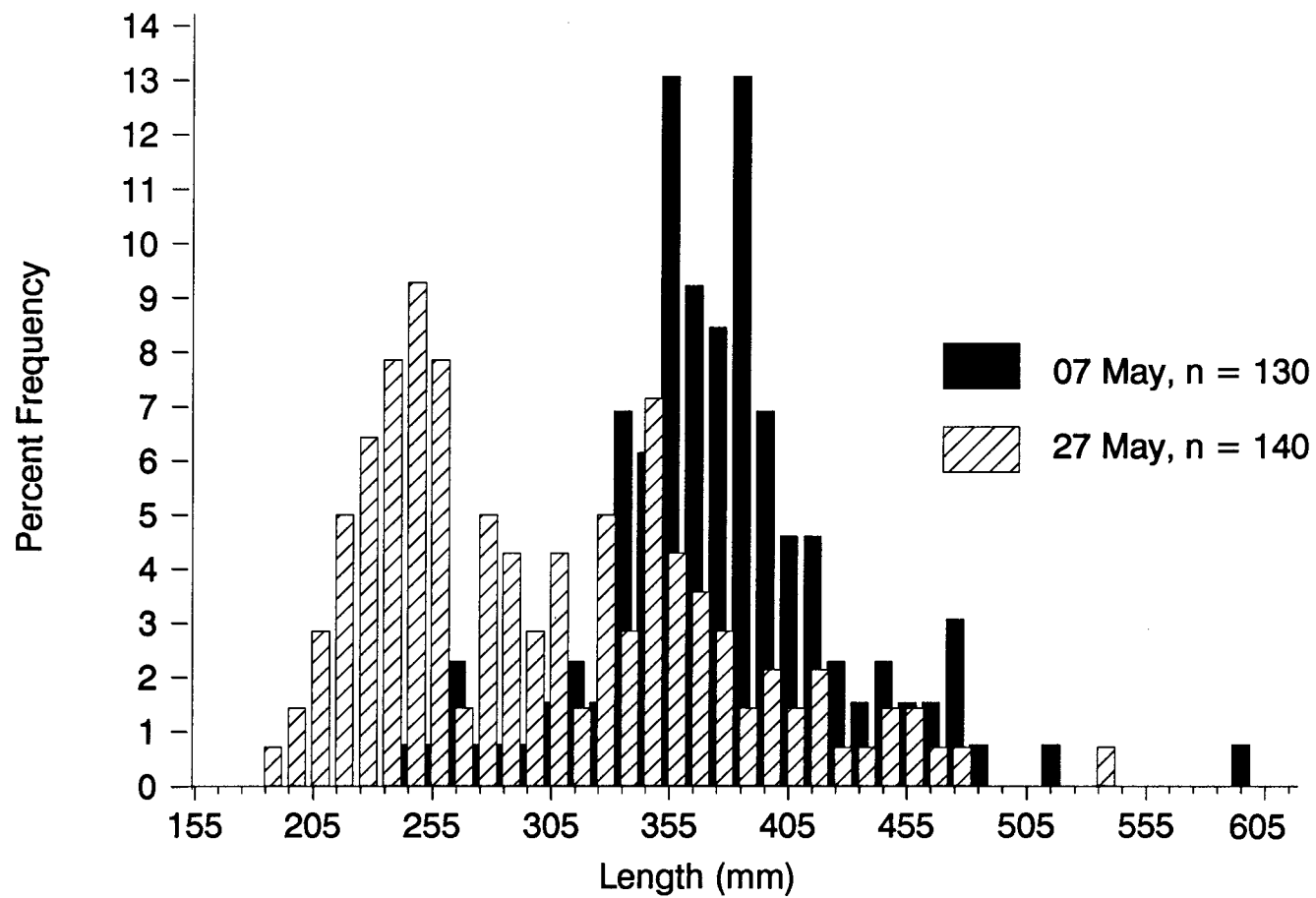


Figure 5. Length frequencies of Dolly Varden captured with a seine at the Buskin River weir during early and late May, 1989.

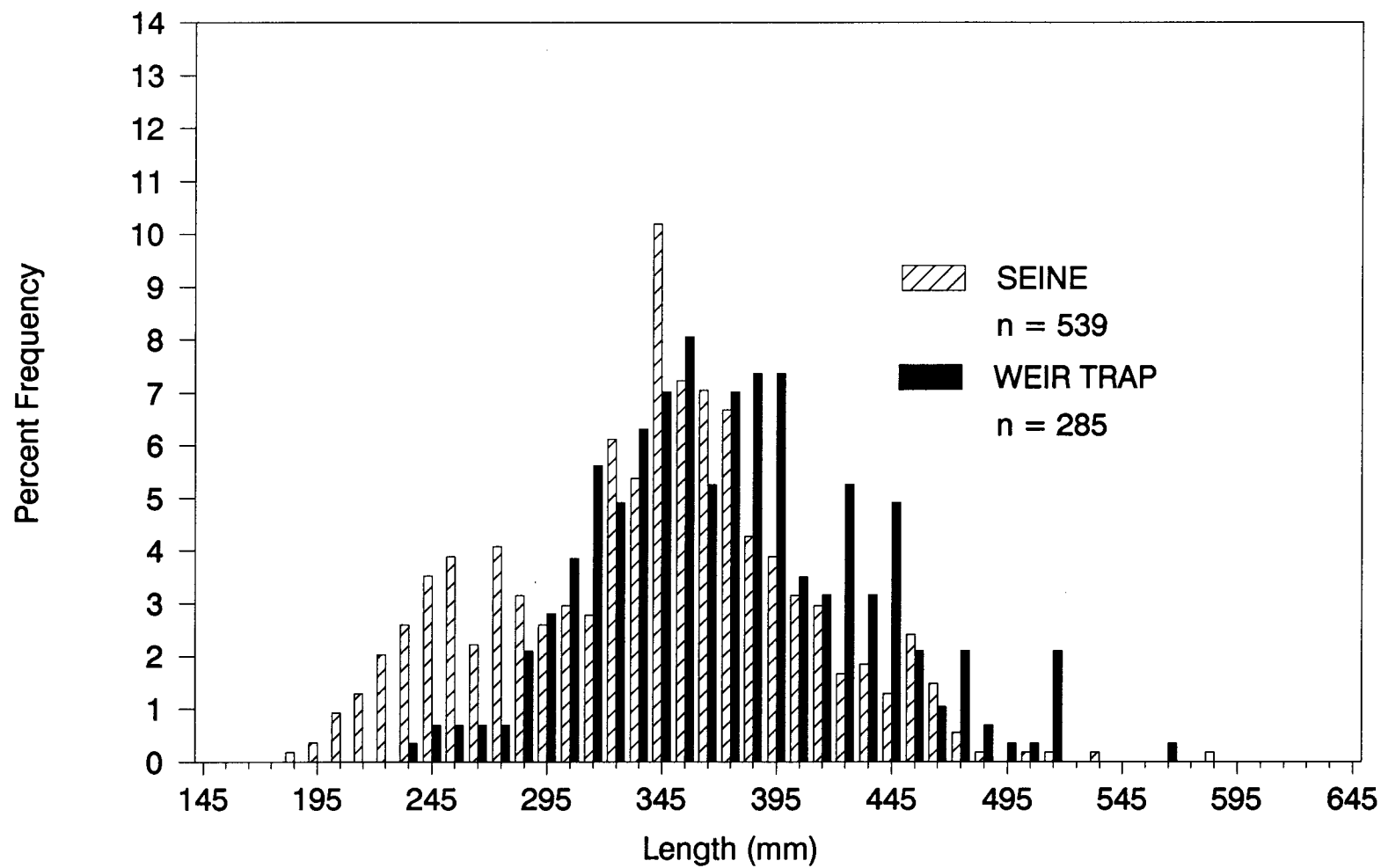


Figure 6. Length frequency of emigrating Dolly Varden sampled in weir trap and of Dolly Varden captured with a seine at the Buskin River weir, May 1989.

Length frequencies of fish measured during the immigration show a significant component of the immigration was fish over 350 mm (fork length) that may be of spawning size (Figures 7 and 8). If these large fish are spawners, then our previous hypothesis that there is not a significant spawning population in the Buskin is incorrect. The length distributions of the immigrants were significantly different over time (with $A^2_{akN} = 45.11$, $\sigma^2_N = 2\ 8702$, and $T_{akN} = 23.756$, with the critical value of 1.86 for T_{akN}) (Tables 6 and 7).

Age classes 3 through 12 were present in the 1989 Dolly Varden emigration past the Buskin River weir (Table 8). The sample was dominated by age 5 (40.2%, SE = 3.07) and age 6 (20.7, SE = 2.54) fish. The mean length for age 5 Dolly Varden was 302 mm (SE = 5) and for age 6 was 328 (SE = 6) (Table 9).

Coho salmon sampled at the Buskin River weir in October 1989 were mostly age 2.1 (Table 10). The mean length for age 2.1 coho salmon was 643 mm (SE = 3) (Table 11).

POPULATION ESTIMATES

Methods

Single year Petersen mark-recapture experiments were conducted to estimate the size of Dolly Varden populations at the fall concentration areas in the Buskin, American, and Olds rivers. Two samples were taken at each site. Sample areas in the Buskin and American rivers were divided into two sublocations and the Olds River was divided into four sublocations to allow testing for equal mixing of marked and unmarked fish between sampling events. At least one day was allowed between sampling events at each site to give time for mixing of marked and unmarked fish. A beach seine was used to capture fish and numbered Floy tags were used to mark all fish captured. Captured fish were also given adipose fin clips. All fish captured were measured for fork length and examined for Floy tags and adipose clips from previous tagging events.

To achieve unbiased estimates from experiments of this type, the following assumptions must be met (from Ricker 1975 and Begon 1979):

1. Marked fish have the same chance of being recaptured as unmarked fish;
2. marked fish have the same chance of dying or emigrating as unmarked fish;
3. there are no births or immigrations;
4. the marked fish do not lose their marks;
5. the marked fish become randomly mixed with the unmarked fish throughout the study area, or the distribution of fishing effort (in

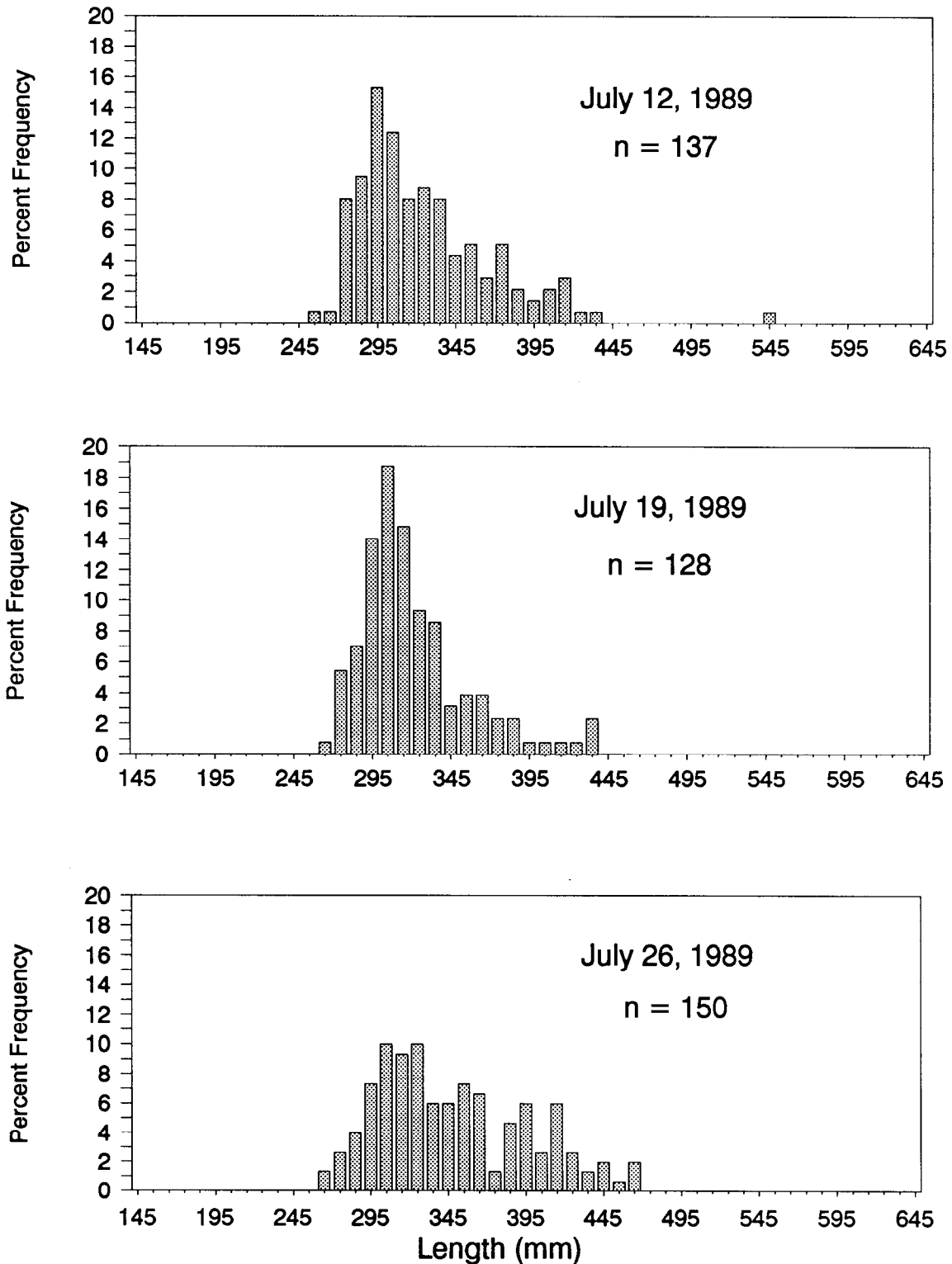


Figure 7. Length frequencies of immigrating Dolly Varden sampled at the Buskin River weir, July 1989.

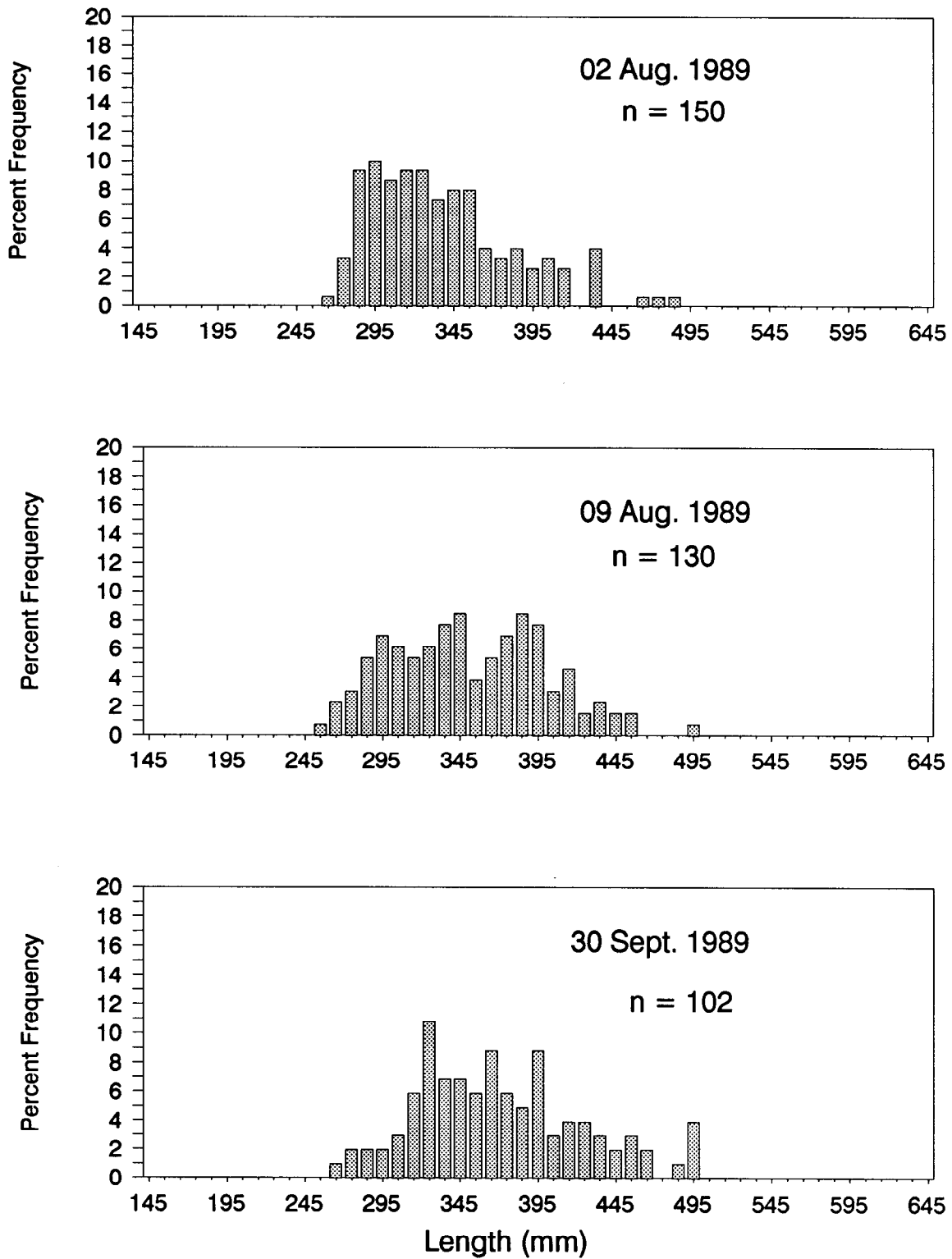


Figure 8. Length frequencies of immigrating Dolly Varden sampled at the Buskin River weir, August and September, 1989.

Table 6. T_{akN} values from Anderson-Darling tests comparing lengths of immigrating Dolly Varden samples from the weir trap in 1989.^{a,b}

	12 July	19 July	26 July	02 Aug	09 Aug	30 Sept
12 July	---					
19 July	-0.025	---				
26 July	11.480*	14.623*	---			
02 Aug	3.914*	6.246*	1.219	---		
09 Aug	14.065*	19.097*	-0.172	3.565*	---	
30 Sept	30.494*	36.939*	6.750*	14.976*	3.591*	---

^a An * indicates a significant difference in the length distribution at $\alpha = 0.05$.

^b Overall $T_{akN} = 23.756$.

Table 7. Length statistics for Dolly Varden captured in the Buskin River weir trap, July - September, 1989.

	Sample Size	Fork Length (mm)			
		Mean	SE	Minimum	Maximum
12 July	137	325.3	4	260	548
19 July	128	321.8	3	265	437
26 July	150	348.4	4	263	468
02 Aug	150	338.8	4	270	490
09 Aug	130	351.7	4	260	491
30 Sept	102	371.2	5	265	499

Table 8. Age distribution of Dolly Varden sampled at the Buskin River weir, 20 - 22 May, 1989.

	Age										Total
	03	04	05	06	07	08	09	10	11	12	
Females											
Sample Size	4	28	69	31	21	5	1				159
% of Sample	1.6	10.9	27.0	12.1	8.2	2.0	0.4				62.1
SE	0.78	1.95	2.78	2.04	1.72	0.87	0.39				3.04
Males											
Sample Size	2	14	34	16	10	6	2	1		1	86
% of Sample	0.8	5.5	13.3	6.3	3.9	2.3	0.8	0.4		0.4	33.6
SE	0.55	1.42	2.13	1.52	1.21	0.95	0.55	0.39		0.39	2.96
Sex not recorded											
Sample Size				6	3	1			1		11
% of Sample				2.3	1.2	0.4			0.4		4.3
SE				0.95	0.67	0.39			0.39		1.27
All											
Sample Size	6	42	103	53	34	12	3	1	1	1	256
% of Sample	2.3	16.4	40.2	20.7	13.3	4.7	1.2	0.4	0.4	0.4	100.0
SE	0.95	2.32	3.07	2.54	2.13	1.32	0.67	0.39	0.39	0.39	

Table 9. Mean fork length at age (mm) of Dolly Varden sampled at the Buskin River weir, 20 - 22 May, 1989.

	Age										
	03	04	05	06	07	08	09	10	11	12	Total
Females											
Average Length	199.50	264.75	302.88	332.39	367.29	374.20	365.00				310.46
SE	14.84	13.43	6.27	6.90	11.00	11.49					5.04
Sample Size	4	28	69	31	21	5	1				159
Minimum	160	192	212	271	272	341	365				160
Maximum	232	507	473	425	477	406	365				507
Males											
Average Length	193.00	266.21	300.59	317.75	386.70	397.67	505.50	465.00		422.00	320.56
SE	35.00	11.51	7.10	12.32	15.82	19.46	25.50				7.59
Sample Size	2	14	34	16	10	6	2	1		1	86
Minimum	158	215	220	275	320	322	480	465		422	158
Maximum	228	335	408	478	470	467	531	465		422	531
Sex not recorded											
Average Length				341.00							341.00
SE											
Sample Size				1							1
Minimum				341							341
Maximum				341							341
All											
Average Length	197.33	265.24	302.13	327.69	373.55	387.00	458.67	465.00		422.00	314.11
SE	13.10	9.65	4.79	6.07	9.03	11.87	49.09				4.21
Sample Size	6	42	103	48	31	11	3	1		1	246 ^a
Minimum	158	192	212	271	272	322	365	465		422	158
Maximum	232	507	473	478	477	467	531	465		422	531

^a Ten fish in Table 12 were not measured for length.

Table 10. Age distribution of coho salmon sampled at the Buskin River weir, October 1989.

	Age						
	1.1	2.0	2.1	2.2	3.0	3.1	Total
<hr/>							
Females							
Sample Number	10		85	1		3	99
% of Sample	4.3		36.5	0.4		1.3	42.5
SE	1.33		3.16	0.43		0.74	3.25
Males							
Sample Number	17	6	106		1	3	133
% of Sample	7.3	2.6	45.5		0.4	1.3	57.1
SE	1.71	1.04	3.27		0.43	0.74	3.25
Sex not recorded							
Sample Number	1						1
% of Sample	0.4						0.4
SE	0.43						0.43
All							
Sample Number	28	6	191	1	1	6	233
% of Sample	12.0	2.6	82.0	0.4	0.4	2.6	100.0
SE	2.13	1.04	2.52	0.43	0.43	1.04	

Table 11. Mean length at age of coho salmon sampled at the Buskin River weir, October 1989.

	Age						
	1.1	2.0	2.1	2.2	3.0	3.1	Total
Females							
Average Length	625.00		647.35	645.00		660.00	645.45
SE	9.34		3.25			12.58	3.03
Sample Size	10		85	1		3	99
Minimum	590		560	645		645	560
Maximum	680		715	645		685	715
Males							
Average Length	608.53	323.33	640.20		320.00	668.33	620.08
SE	16.27	10.38	5.02			40.45	7.68
Sample Size	17	6	106		1	3	133
Minimum	490	285	450		320	600	285
Maximum	700	345	755		320	740	755
Sex not recorded							
Average Length	650.00						650.00
SE							
Sample Size	1						1
Minimum	650						650
Maximum	650						650
All							
Average Length	615.89	323.33	643.38	645.00	320.00	664.17	630.99
SE	10.47	10.38	3.14			19.04	4.64
Sample Size	28	6	191	1	1	6	233
Minimum	490	285	450	645	320	600	285
Maximum	700	345	755	645	320	740	755

subsequent sampling) is equivalent to the distribution of fish throughout the study area; and

6. all fish have an equal chance of being caught.

If the above assumptions are met the abundance of the entire population can be estimated using (Ricker 1975):

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)} \quad (19)$$

with variance:

$$V(\hat{N}) = \frac{N^2(C-R)}{(C+1)(R+2)} \quad (20)$$

Mortality and Migration:

We have no evidence that marking with Floy anchor tags causes behavioral changes or increased mortality that would alter the capture probability of the marked fish (assumption 1). Obviously these rivers are not closed systems, however we felt that by October there would be little, if any, movement into the concentration areas. There may have been emigration, but we had no reason to believe that the rate of emigration was any greater for tagged fish than for untagged fish (assumptions 2 and 3).

Tag Loss:

To test assumption 4, Dolly Varden tagged during emigration in the spring of 1989 were also given an adipose fin clip. Prior to tagging, each fish was checked to see if it was already missing its adipose fin. This gave us an estimate of the percent of fish in the population that were naturally missing their adipose fin. Out of 4,422 fish examined, 51 were already missing their adipose fin, resulting in an estimate of 1% naturally missing fins (SE = 0.15). Fish naturally missing their adipose fins were spread approximately equally across all length groups (Figure 9, chi-square test of 100 mm length groups = 0.330, df = 2, 0.975 < P < 0.99).

All fish recaptured during the fall population estimates were examined for a missing adipose fin which would indicate loss of the tag during the summer. Unfortunately, adipose fins were also clipped on new captures during the population estimates. So, after the population estimate was begun (especially during event 2), there were adipose clips from the spring emigration and clips from the current tagging event mixed together in the population.

At the fall sampling in the Buskin River in event 1 (the tagging event) of the population estimate ten fish with tags from the 1989 emigration tagging were recaptured. An additional 38 fish with missing adipose fins were captured. This results in a estimate of 78% tag loss (SE = 6) during the period from May 1989 to October 1989 (taking into account the 1% natural background level of

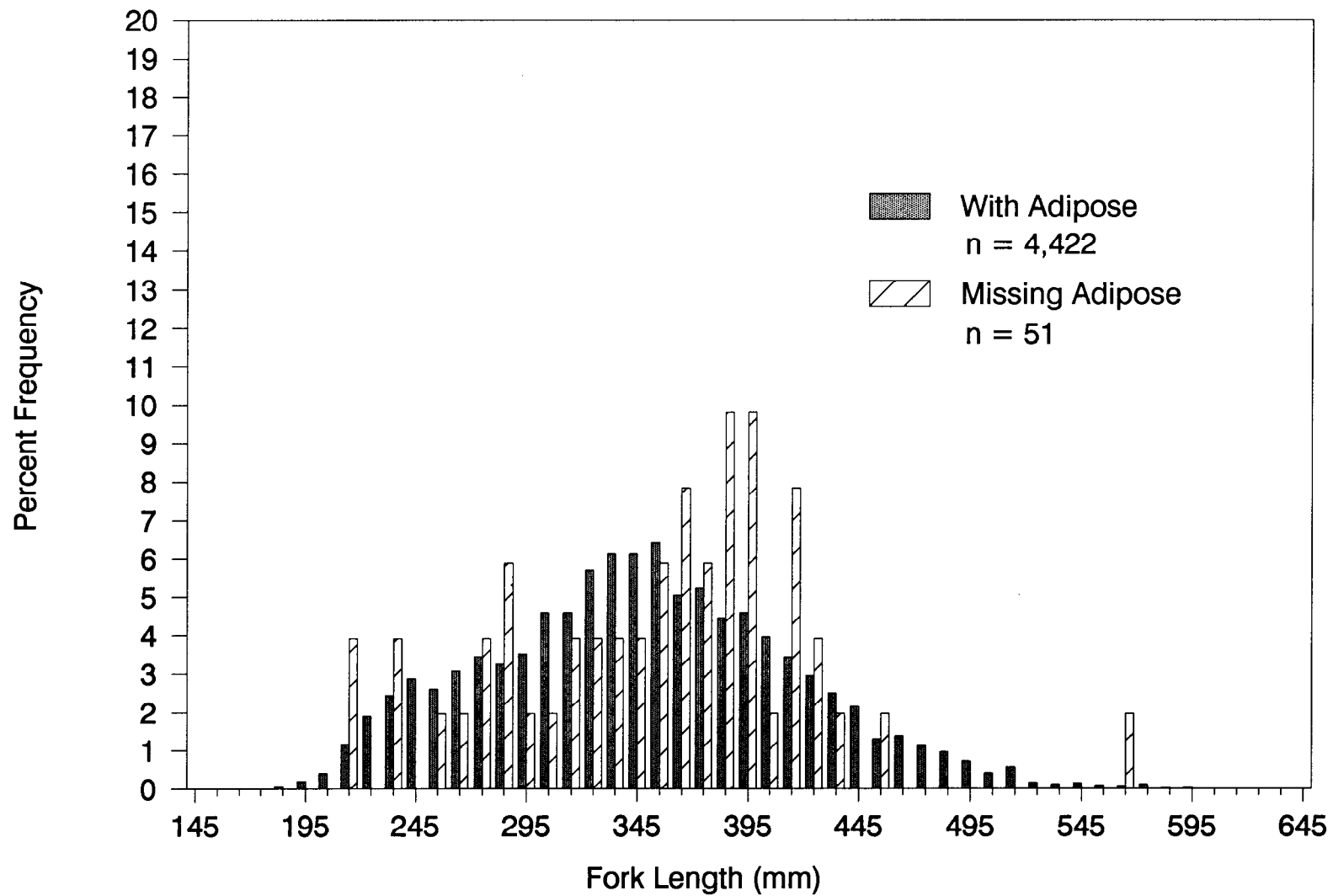


Figure 9. Length frequency of Dolly Varden with adipose fins and of Dolly Varden naturally missing their adipose fins from fish collected with a seine for tagging at the Buskin River weir, May 1989.

missing adipose fins, Table 12). This is assuming that none of the 38 fish with missing fins were from the current tagging event. If fish from event 1 were quickly losing their tags we would expect to see a higher percent of missing-adipose fish among the fish examined during the second event two days later. However, the percent of all fish captured that did not have an adipose fin did not increase from event 1 to event 2 (chi-square = 0.403, df = 1, 0.50 <P< 0.75).

At the American River in event 1 there were 23 recaptures of fish with tags from the 1989 emigration. Just three more were found with missing adipose fins, resulting in an estimate of 10% tag loss (SE = 6) (Table 12). The Olds River was similar, with 15 recaptures with tags and 2 with missing adipose fins, resulting in an estimate of 11% tag loss (SE = 8) (Table 12).

The fish captured at the Buskin River were relatively small (98% \leq 350 mm), while those at the American and Olds rivers were large (generally over 350 mm).

The above tag loss estimates are for fish at large for three months. We do not know how much of that tag loss would occur in the first few days after release. At the Buskin River, (where most of the small fish, most prone to tag loss were tagged) we released 1,762 fish with adipose clips into the population during event 1 on 11 October. If those fish were rapidly losing their tags, we might expect to have found many more fish without adipose fins among the fish captured in event 2. We did not. The percent of all fish captured that were without adipose fins remained about the same between the two events.

Members of the crew that was tagging fish in October reported that the adipose fins on small Dolly Varden were very hard to see. They speculated that they may have frequently recorded that a fish was missing its adipose fin when the fin was actually there. This is supported by the fact that 24 of the fish described as missing their adipose fins were less than 250 mm fork length. Only 400 fish less than 250 mm were tagged and given adipose clips in the spring of 1989. Even these fish would be expected to have grown roughly 50 mm over the course of the summer, so it is unlikely that a fish less than 250 mm in the fall could have been tagged and clipped in the spring.

In the spring of 1990, six of the missing-adipose fish from fall 1989 tagging were recaptured. None of them had grown over the winter, so they were still small fish with difficult to see adipose fins. The spring 1990 tagging crew saw an adipose fin on one of the six. This lends some further support to the theory that the fall 1989 tagging crews mistakenly identified many small fish as missing their adipose fins.

My conclusion is that the question of tag loss has not been adequately addressed and needs to be studied further before we can begin to trust the estimates of tag loss. I did not incorporate estimates of tag loss into the population estimates. If the rate of tag loss really is as high as estimated, then the population size estimates (especially for the small fish in the Buskin River) are too high. These population estimates should be used with caution until this question is settled.

Table 12. Estimated rate of tag loss from 1989 emigration tagging during 1989 population estimates at Buskin, American and Olds rivers.

Length at Recapture (mm)	Number Examined	Recap. With Only ad Clip	Recap. With Tag & ad Clip	% Tag Loss ^a	SE
<u>Buskin River</u>					
Event 1					
<= 300	1,756	29	1	96%	3
300<x<=350	402	8	7	52%	13
> 350	70	1	2	32%	33
All lengths	2,234 ^b	38	10	78%	6
Event 2					
<= 300	1,944	25	2	91%	5
300<x<=350	285	8	0	99%	0
> 350	30	0	0		
All lengths	2,319 ^c	33	2	93%	4
<u>American River</u>					
Event 1					
<= 300	4	0	0		
300<x<=350	20	0	0		
> 350	370	3	23	10%	6
All lengths	395 ^d	3	23	10%	6
Event 2					
<= 300	5	0	0		
300<x<=350	36	0	1	0%	
> 350	510	2	25	6%	5
All lengths	551	2	26	6%	5
<u>Olds River</u>					
Event 1					
<= 300	28	1	0	99%	
300<x<=350	178	0	1	0%	
> 350	416	1	14	6%	7
All lengths	624 ^e	2	15	11%	8
Event 2					
<= 300	18	0	0		
300<x<=350	54	0	1	0%	
> 350	137	1	5	16%	17
All lengths	252 ^f	1	6	13%	14

^a Assuming 1% naturally missing adipose fins.

^b 6 fish not measured.

^c 60 fish not measured.

^d 1 fish not measured.

^e 2 fish not measured.

^f 43 fish not measured.

Distribution of Tagged Fish:

Contingency table analyses were used to test for equal mixing of marked and unmarked fish between sampling events and equal probability of capture of fish from all sublocations during the marking event. The test compared the ratio of marked to unmarked fish in event two at each sublocation (Table 13). In the Buskin River the marked to unmarked ratios were not significantly different between sublocations at $\alpha = 0.05$. For the American and Olds rivers the ratios were significantly different at $\alpha = 0.05$, indicating that a separate population estimate should be done for each sublocation or group of sublocations. For the Olds River, the marked to unmarked ratios were the same for sublocations 1 and 2 (Table 14, $0.50 < P < 0.75$), but were significantly different between sublocations 1 and 2 and sublocations 3 and 4 (Table 14, $0.01 < P < 0.025$). Therefore, to achieve an unbiased estimate of population abundance, the Olds River population estimate should be divided into sublocation 1 and 2 and sublocation 3 and 4.

For the American and Olds rivers the appropriate estimator is a stratified Petersen (Seber 1982 section 11.1.1). The stratified estimator (\underline{W}) is:

$$\underline{W} = D_u M^{-1} \underline{a} \quad (21)$$

where:

\underline{W} = a vector with the estimates of the number of untagged Dolly Varden in each sublocation just after the release of the tagged fish,

D_u = a diagonal matrix of the number of untagged fish observed in each recovery sublocation j ,

M = a matrix of m_{ij} , the number of tagged fish in each recovery sublocation, j , which were released in tagging sublocation i , and

\underline{a} = a vector of the number of tagged fish released in tagging sublocation i .

The number of Dolly Varden in each sublocation at the time of tagging is the sum of the estimated number of untagged fish present and the number of tagged fish released in the sublocation.

The variance-covariance matrix of \underline{W} was estimated with (Seber 1982):

$$E[(\hat{\underline{W}} - \underline{W})(\hat{\underline{W}} - \underline{W})'] = D_w B^{-1} D_u D^{-1} \underline{a} B' - I D_w + D_w (D_p - I) \quad (22)$$

where:

D_w = diagonal matrix of estimated abundance in each sublocation,

D_p = diagonal matrix of reciprocals of p_i , which is the estimated probability of an animal surviving and being caught,

Table 13. Comparison of number of marked fish in event 2 to number of unmarked fish in event 2 at sublocations within the Buskin, American, and Olds rivers during 1989 population estimates.

Site	Subloc 1	Subloc 2	Subloc 3 & 4
<u>Buskin River</u>			
Marked	36	13	---
Unmarked	1584	686	---
Chi-square = 0.310, df = 1, 0.50 < P < 0.75			
<u>American River</u>			
Marked	25	28	---
Unmarked	310	191	---
Chi-square = 4.337, df = 1, 0.025 < P < 0.05			
<u>Olds River</u>			
Marked	20	11	9
Unmarked	82	37	93
Chi-square = 6.645, df = 2, 0.005 < P < 0.01			

Table 14. Comparison of number of marked fish in event 2 to number of unmarked fish in event 2 at pairs of sublocations within the Olds River during 1989 population estimates.

	Subloc 1	Subloc 2
Marked	20	11
Unmarked	82	37
Chi-square = 0.218, df = 1, 0.50<P<0.75		

	Subloc 1&2	Subloc 3&4
Marked	31	9
Unmarked	119	93
Chi-square = 6.377, df = 1, 0.01<P<0.025		

B = matrix of b_{ij} , the probability that a member of a_i is in sublocation j at sampling and that it is alive,

I = the identity matrix,

and;

$$B = D^{-1}MD_q . \quad (23)$$

The variance of the point estimate for the total number of Dolly Varden present is the sum of the variance and covariance estimates for the individual strata.

Assumptions necessary for the stratified abundance estimates are the same as for the unstratified Petersen except that capture probabilities for fish in different sublocations need not be the same but tagged fish are assumed to behave independently of one another with regard to moving among sublocations (Seber 1982).

Size Selectivity:

To test for equal capture probabilities of different sizes of fish, either Anderson-Darling or chi-square tests were used to compare the length frequencies of fish marked during the first event and those recaptured during the second event. Significance of these comparisons would suggest that there is size selectivity in the sample from the second event. I also compared the length frequency of all fish captured during the first event to the length frequency of all fish captured during the second event. This tests for a difference in the size distribution between the two events.

At the American River I found no size selectivity in the second event (Figure 10, with $A^2_{akN} = 0.3090$, $\sigma^2 = 0.5762$, and $T_{akN} = -0.910$, with a critical value of 1.96 for T_{akN}), but there was a difference in size distribution between the two events (Figure 10, with $A^2_{akN} = 8.7271$, $\sigma^2 = 0.5774$, and $T_{akN} = 10.169$, with a critical value of 1.96 for T_{akN}), indicating that there must have been size selectivity in the first event. Since one of the two samples was random with respect to size it was not necessary to stratify the American River population estimate by size.

At the Olds River, there was no size selectivity in the second event (Figure 11, with $A^2_{akN} = 1.2664$, $\sigma^2 = 0.5788$, and $T_{akN} = 0.350$, with a critical value of 1.96 for T_{akN}), and the size distribution from the first event was the same as the size distribution in the second event (Figure 11, with $A^2_{akN} = 0.8978$, $\sigma^2 = 0.5772$, and $T_{akN} = -0.135$, with a critical value of 1.96 for T_{akN}). Therefore stratification by size group was also not necessary for the Olds River.

At the Buskin River the sample sizes were so large that the Anderson-Darling test program could not be used. Instead I used chi-square tests on 50 mm length groups. There was size selectivity in the sample from the second event for fish between 150 and 300 mm (chi-square = 15.438, df = 2, $P < 0.001$)

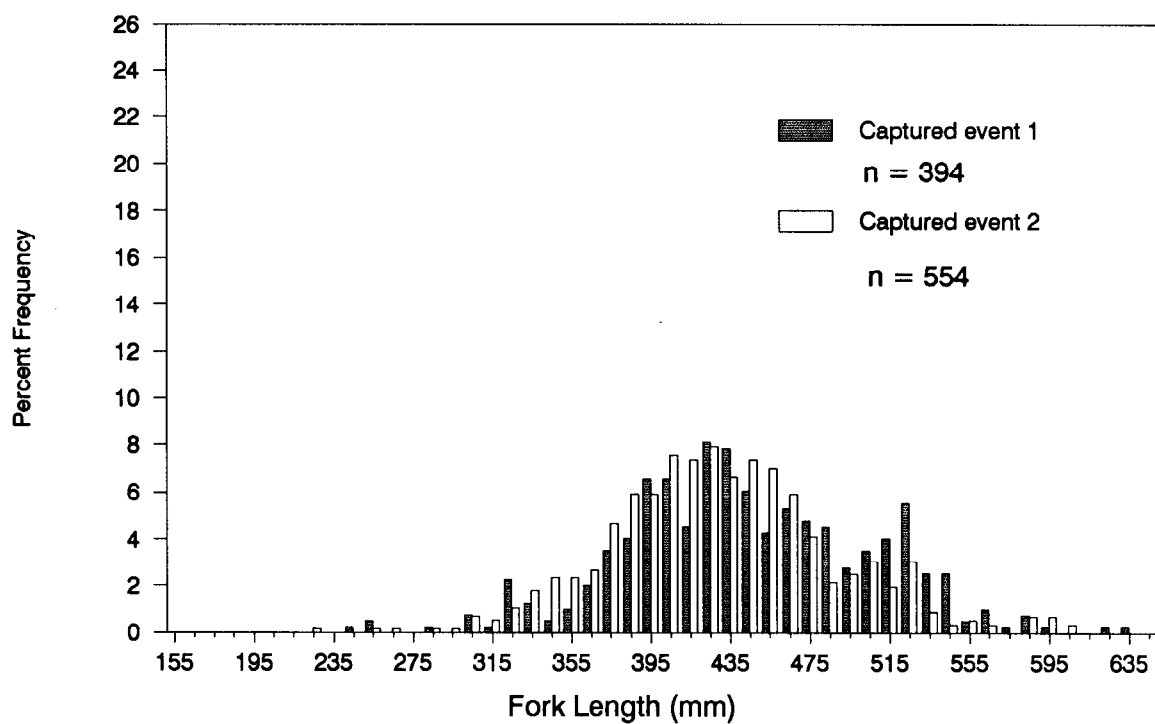
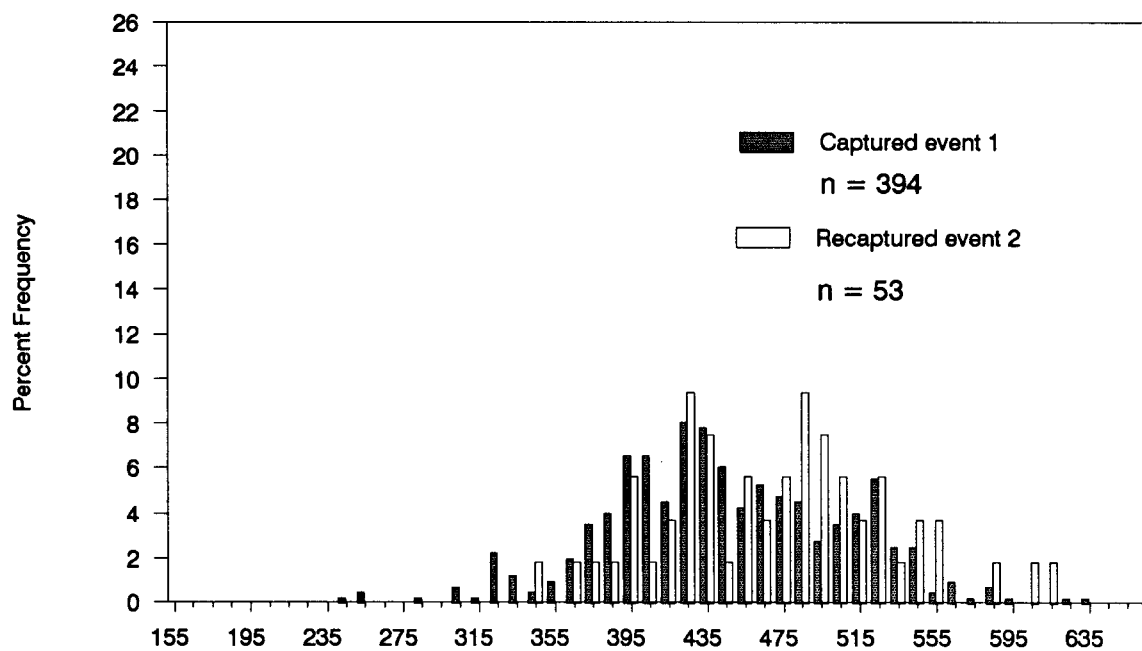


Figure 10. Length frequencies used to test for size selectivity in event 2 of the population estimate (top graph) and for equal size distribution between event 1 and event 2 (bottom graph) at the American River, October 1989.

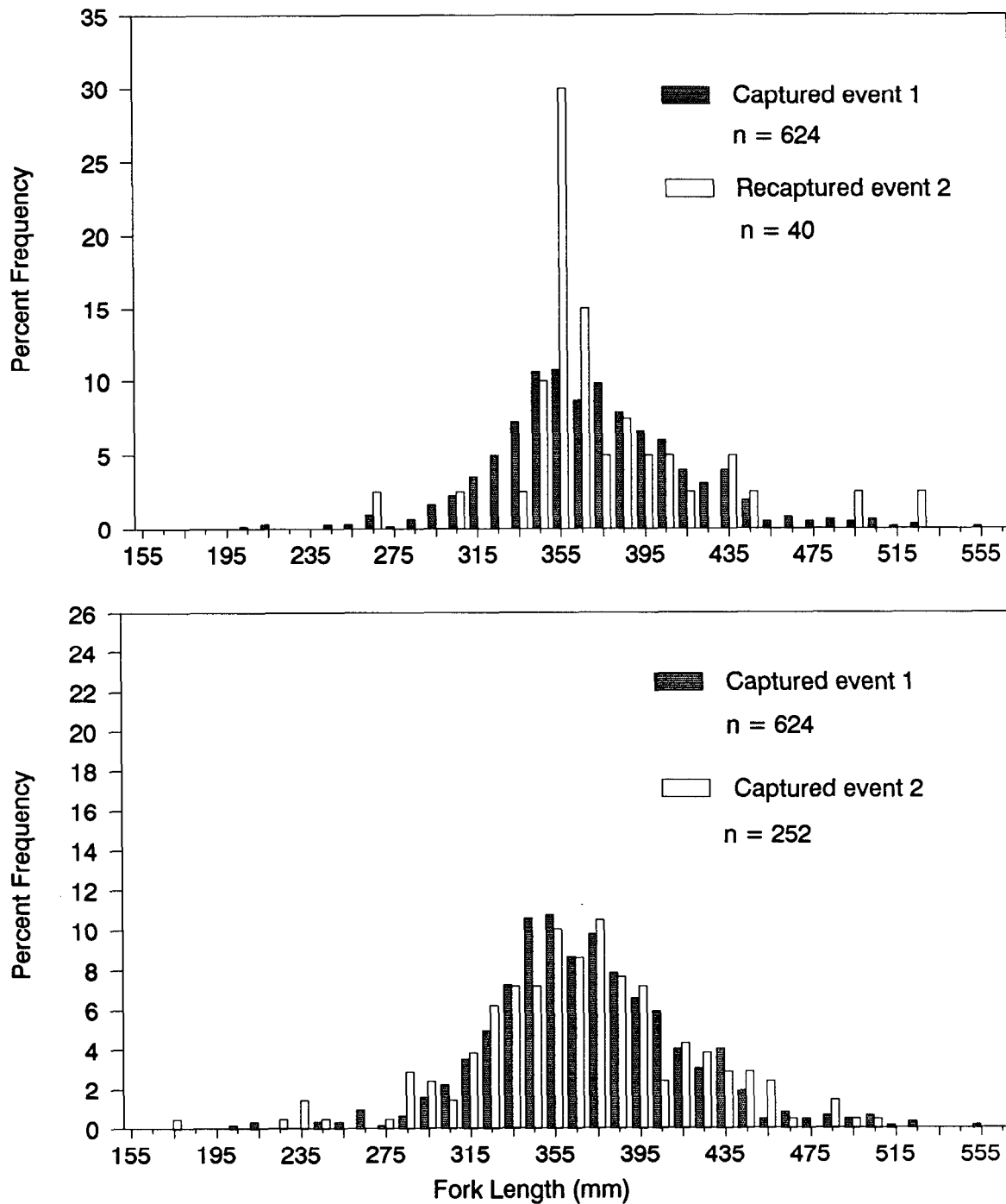


Figure 11. Length frequencies used to test for size selectivity in event 2 of the population estimate (top graph) and for equal size distribution between event 1 and event 2 (bottom graph) at the Olds River, October 1989.

(Figure 12). Fish larger than 300 mm were not included in the test because there were no recaptures of fish that large. There was no size selectivity in the second event when only fish in the range 151 - 250 mm were tested (chi-square = 0.678, df = 1, $0.25 < P < 0.50$). From these tests it appears that large fish (> 250 mm) that were tagged in the first event had a lower probability of being recaptured than small fish.

Chi-square tests comparing the length frequency of all fish in the first event to all fish in the second event (Figure 12) were significant (chi-square = 60.013, df = 6, $P < 0.001$), however, given the large sample size in both groups it is likely that even differences of no practical significance between the two length frequencies would result in a statistically significant test. The two length frequencies appear very similar (Figure 12) and I believe they are not meaningfully different.

My conclusion is that the length frequencies of all fish in the two events at the Buskin River are the same, but large fish that were marked in the first event do not appear among the recaptures. Large fish were still in the sample area during event 2, but these were not the same fish that were there in event 1. Apparently fish > 250 mm were moving through the area during the population estimate. None of the 471 fish > 300 mm that were tagged in event 1 were recaptured. This indicates that fish in this size class may have had an even lower recapture probability than those between 250 and 300. As a result, I chose to confine the population estimate to only those fish less than or equal to 300 mm, and to stratify that group into two size classes: ≤ 250 mm, and > 250 but ≤ 301 mm.

Results

The population size estimate for the American River in October of 1989 (Table 15) was 4,125 Dolly Varden (SE = 805.22). For the Olds River I attempted to do a stratified Petersen estimate, but could not because there were negative capture probabilities (p_j) in sublocations 3 and 4. The non-stratified Petersen population size estimate (Table 15) was 3,856 Dolly Varden (SE = 544.61), however this is a biased estimate due to significant differences in capture probabilities between sublocations.

In the Buskin River, the estimate for small fish (less than or equal to 250 mm) was 25,003, and the estimate for larger fish (greater than 250 mm but less than or equal to 300 mm) was 75,427 (Table 15). As described in the methods, no estimate could be made for fish greater than 300 mm in the Buskin River as these fish were apparently moving through the area at the time of our estimate.

DISCUSSION

The estimate of Dolly Varden harvest from the 1989 creel survey is roughly 2,000 fish higher than the 1988 harvest of 3,569 fish (Murray 1989). Harvest estimates from the statewide harvest survey declined dramatically in 1987 (Figure 13) and have remained relatively low since that time. The number of fish harvested, however, is still low in comparison to the abundance estimate of over 100,000 Dolly Varden less than 300 mm and a weir count of roughly

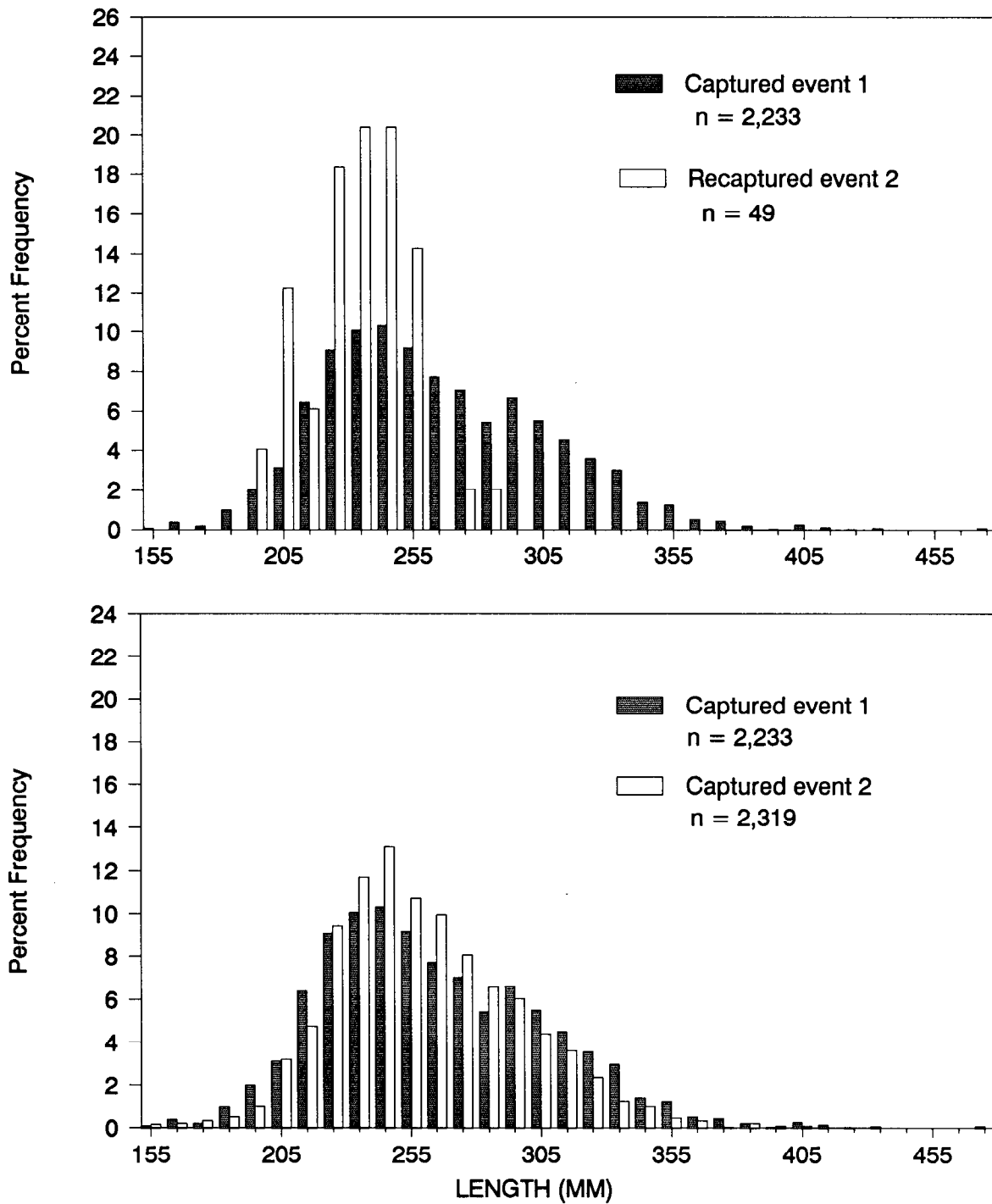


Figure 12. Length frequencies used to test for size selectivity in event 2 of the population estimate (top graph) and for equal size distribution between event 1 and event 2 (bottom graph) at the Buskin River, October 1989.

Table 15. Population size estimates of Dolly Varden concentrations in Buskin, American, and Olds rivers, October 1989.

	Buskin R.		American R.	Olds R.
	Small Fish ^a	Large Fish ^b		
Event 1				
Date	11 Oct 89		10 Oct 89	3-5 Oct 89
Number marked	958	804	394	624
Event 2				
Date	13 Oct 89		12 Oct 89	10 Oct 89
Number captured	1,068	936	551	252
Number recaptured	40	9	53	40
Population Estimate	25,003	75,427	4,125	3,856
Standard Error	3,783.34	30,118.77	805.22	544.61
95% CI				
Lower bound	17,588	16,394	2,547	2,789
Upper bound	32,418	134,460	5,703	4,923
Relative Precision	29.7%	78.3%	38.3%	27.7%

^a Dolly Varden less than or equal to 250 mm fork length.

^b Dolly Varden greater than 250 mm fork length but less than or equal to 300 mm fork length.

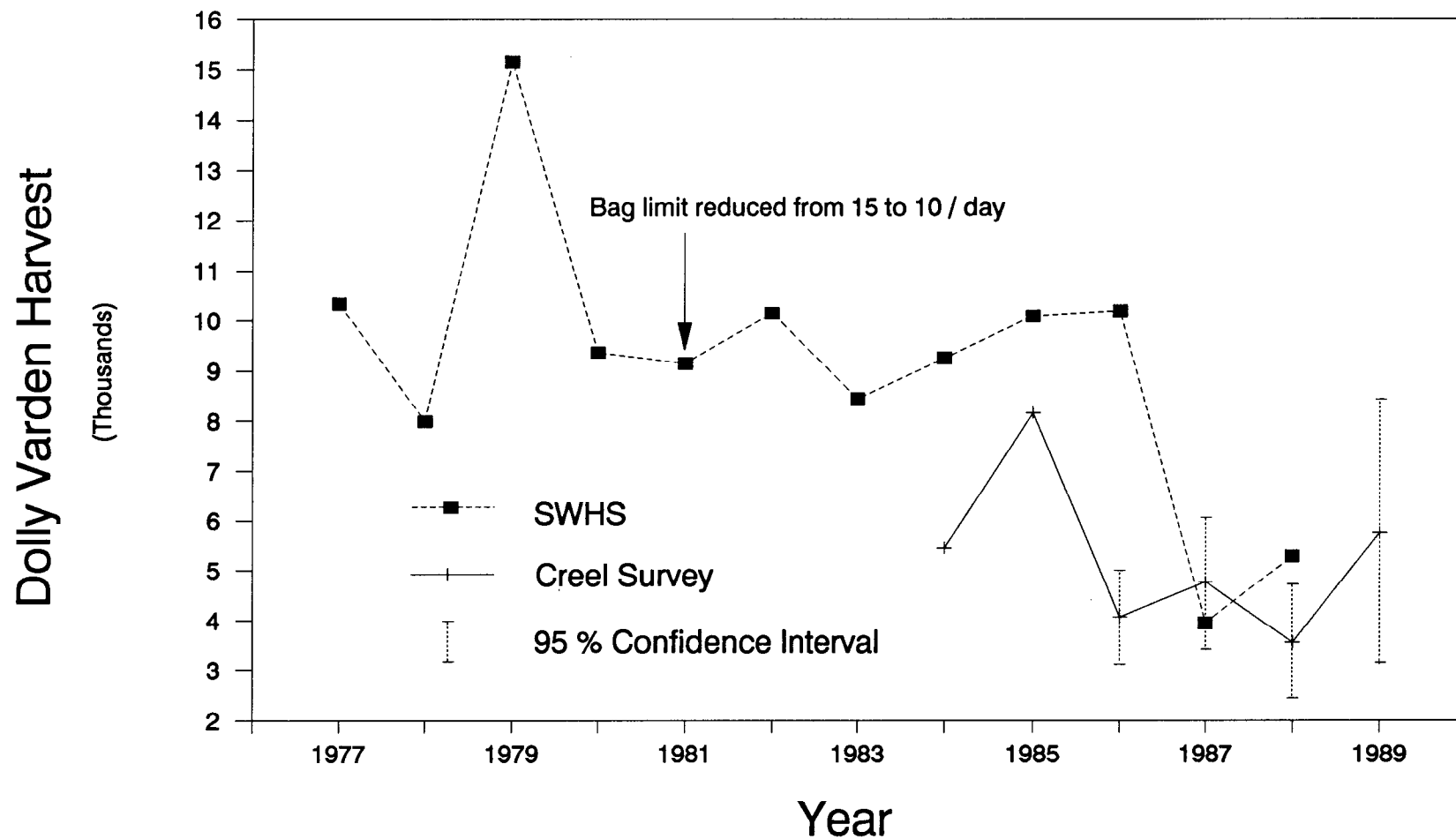


Figure 13. Dolly Varden harvest estimates from the statewide harvest survey (Mills 1977-1989) and from on-site creel surveys (Murray 1984-1989).

30,000 larger Dolly Varden in the Buskin River in October 1989. It seems unlikely that the reduction in harvest is due to low abundance.

Data from population estimates in the Buskin, American, and Olds rivers all indicate movement of Dolly Varden within the streams during the population estimates. In the American River, the number of marked fish in event 2 was lower than expected in sublocation 1, the upstream sublocation. This may be due to a trend towards emigration from the river. In the Olds River, the number of marked fish was lower than expected in sublocations 3 and 4. All of this information challenges our assumption that there is little movement into or out of the river systems during the population estimates. If we continue to do population estimates in spawning streams we need to get a measure of the extent of this movement.

In the Buskin River, we could not estimate the population of fish > 300 mm because these fish had a very low probability of being recaptured and were apparently moving through the area at the time of the estimates. Our immigrant weir sampling shows that there are large fish (> 300 mm) in the river in October, but we are not adequately sampling these fish during the population estimates. In 1990 we will survey the river and Buskin Lake shores and tributaries in an attempt to find concentrations of these larger fish.

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APPENDIX A

Appendix A1. Number of anglers counted during each period surveyed, Buskin River creel survey, 1989.

Date	Day	Period		
		A (0700-1159)	B (1200-1659)	C (1700-2200)
22-Apr	SA	0	1	4
23-Apr	SU	3	13	17
24-Apr	M	2	8	6
25-Apr	T		11	8
26-Apr	W			
27-Apr	TH			
28-Apr	F		9	3
29-Apr	SA		24	
30-Apr	SU		42	36
01-May	M			
02-May	T			
03-May	W	3		2
04-May	TH		5	17
05-May	F		7	3
06-May	SA	3	18	6
07-May	SU		18	7
08-May	M			
09-May	T	5	7	34
10-May	W		34	49
11-May	TH			
12-May	F			
13-May	SA	7	24	21
14-May	SU		18	3
15-May	M			
16-May	T			
17-May	W	4	10	11
18-May	TH			
19-May	F		5	13
20-May	SA	11	40	
21-May	SU	5	37	8
22-May	M		2	3
23-May	T	4		8
24-May	W			
25-May	TH			
26-May	F		5	2

Appendix A2. Daily angler effort, catch, and harvest statistics from completed trip anglers, Buskin River April 22 - May 26, 1989.

Date	Period	WE/ WD	Number of Interviews	Mean Effort	S ² _e	Mean Catch	S ² _c	CPUE,*†	2* S2hi	Mean Harvest	S ² _h	HPUE,*†	2* S2hi
890423	A	WE	4	1.09	1.1163	0.31	0.3844	0.2994	0.1061	0.31	0.3844	0.2994	0.1061
890506	A	WE	10	2.18	1.1893	3.54	13.4485	1.6201	0.2275	0.93	4.0479	0.4408	0.0777
890513	A	WE	6	1.22	2.0157	12.79	559.1667	12.7108	28.6251	2.66	16.2927	2.3538	0.3627
890520	A	WE	5	2.00	2.3750	28.68	597.2456	14.3155	5.1094	5.01	58.0262	2.6015	2.8303
890521	A	WE	4	1.27	0.8516	0.32	0.1365	0.2689	0.0057	0.05	0.0110	0.0441	0.0019
890422	B	WE	8	0.54	0.1005	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890423	B	WE	5	0.73	0.1347	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890429	B	WE	7	1.74	1.8074	0.73	2.3397	0.4652	0.0980	0.73	2.3397	0.4652	0.0980
890430	B	WE	12	1.21	0.5663	2.68	86.2424	2.4805	4.8989	0.89	9.5765	0.8266	0.5440
890506	B	WE	7	2.23	2.3325	5.80	58.6550	2.6769	1.1309	2.85	11.8690	1.2505	0.3218
890507	B	WE	11	1.46	1.8553	3.20	13.7114	1.9868	1.1384	0.56	1.0640	0.3677	0.0469
890513	B	WE	17	0.95	2.0579	2.82	43.3554	3.0378	1.3962	0.54	3.1448	0.5019	0.2820
890514	B	WE	12	0.73	0.2916	3.06	25.0719	4.2235	3.2250	0.51	0.6758	0.6819	0.1140
890520	B	WE	5	2.20	1.2000	7.49	13.9026	3.0991	1.9975	4.08	16.8062	1.5902	1.4526
890521	B	WE	5	1.32	0.8993	1.57	4.9534	1.0234	0.8188	0.00	0.0000	0.0000	0.0000
890422	C	WE	3	0.83	0.0833	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890423	C	WE	13	1.68	1.9751	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890430	C	WE	12	1.46	0.4299	1.18	10.8023	0.7734	0.4473	1.18	10.8023	0.7734	0.4473
890506	C	WE	5	1.25	0.1250	1.88	2.9963	1.4414	0.5239	0.28	0.1767	0.2372	0.0175
890513	C	WE	11	0.82	0.6229	1.80	5.6706	2.0168	1.1830	1.05	2.3130	1.1728	0.4504
890514	C	WE	4	2.38	0.2292	4.18	15.5021	1.6668	0.9935	0.77	1.1130	0.3230	0.0502
890521	C	WE	10	1.03	0.3951	0.25	0.6300	0.2336	0.0636	0.13	0.1563	0.1163	0.0158
890503	A	WD	4	1.44	0.4323	6.87	22.3806	4.8318	0.7914	3.96	20.9972	2.8953	1.5154
890509	A	WD	6	1.58	0.4167	4.63	22.8868	2.9938	0.9176	4.17	23.9136	2.6942	1.1415
890517	A	WD	2	2.50	0.5000	25.00	272.3778	10.5558	7.7238	22.23	417.3161	9.7233	17.3611
890523	A	WD	2	0.59	0.3445	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000

- (continued) -

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Date	Period	WE/ WD	Number of Interviews	Mean Effort	S^2_e	Mean Catch	S^2_c	$\overline{CPUE}^{**\dagger}$	2^{**} S_{2hi}	Mean Harvest	S^2_h	$\overline{HPUE}^{**\dagger}$	2^{**} S_{2hi}
890424	B	WD	2	1.50	0.5000	2.14	9.1165	1.7792	1.1396	2.14	9.1165	1.7792	1.1396
890425	B	WD	3	1.83	0.0833	15.27	415.4506	8.5165	40.2623	14.10	336.6610	7.8518	32.6387
890428	B	WD	3	2.17	1.0833	6.09	55.7697	3.0796	2.5137	3.20	8.6272	1.5774	0.1411
890504	B	WD	7	1.52	0.8007	1.14	1.5598	0.7379	0.0817	1.14	1.5598	0.7379	0.0817
890505	B	WD	8	0.77	0.2472	2.34	9.1682	3.1286	1.1363	1.40	2.9477	1.8061	0.5806
890508	B	WD	15	1.12	0.3113	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890509	B	WD	12	1.15	0.2325	3.43	9.7021	2.9927	0.4890	0.37	0.7623	0.3381	0.0446
890510	B	WD	16	1.23	0.2789	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890517	B	WD	6	2.54	2.2604	1.07	3.1929	0.4272	0.0769	0.54	0.8014	0.2139	0.0193
890519	B	WD	3	1.28	2.2346	0.18	0.0936	-0.1115	0.1484	0.00	0.0000	0.0000	0.0000
890522	B	WD	4	1.63	0.5625	1.18	0.1380	0.7115	0.0037	0.96	0.4096	0.6031	0.0028
890526	B	WD	6	0.39	0.0290	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890425	C	WD	11	1.50	1.9875	0.95	1.3980	0.5715	0.0969	0.83	1.0346	0.5061	0.0656
890428	C	WD	4	1.00	0.0000	0.12	0.0600	0.1225	0.0150	0.12	0.0600	0.1225	0.0150
890503	C	WD	11	0.60	0.2899	0.21	0.1174	0.3234	0.0366	0.21	0.1174	0.3234	0.0366
890504	C	WD	15	1.57	0.3167	3.89	44.2175	2.4678	1.2267	1.48	3.1650	0.9340	0.1007
890505	C	WD	7	1.46	1.5736	0.35	0.8575	0.2093	0.0686	0.00	0.0000	0.0000	0.0000
890508	C	WD	28	1.26	1.1483	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890509	C	WD	22	2.02	1.6326	9.48	160.2054	4.6288	2.0854	0.63	3.6300	0.3133	0.0407
890510	C	WD	9	0.94	0.3403	2.23	16.5023	2.2021	2.3084	2.23	16.5023	2.2021	2.3084
890517	C	WD	3	0.75	0.0625	9.60	85.2180	12.5901	48.7261	4.80	20.4780	6.5101	7.8524
890518	C	WD	7	0.69	0.8119	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890519	C	WD	15	1.65	2.2304	3.75	20.7949	2.1971	0.5704	1.70	8.1890	0.9945	0.2182
890523	C	WD	5	1.95	0.2625	0.00	0.0000	0.0000	0.0000	0.00	0.0000	0.0000	0.0000
890526	C	WD	2	3.50	0.0000	0.16	0.0000	0.0457	0.0000	0.00	0.0000	0.0000	0.0000

Appendix A3. Counts of Dolly Varden, Steelhead, and Salmon through the Buskin River weir, 27 April through 9 October, 1989.

Date	Emigrants		Immigrants		Immigrant Salmon		
	Dolly Varden	Steel-head	Dolly Varden	Steel-head	Sockeye Salmon	Coho Salmon	Pink Salmon
27-Apr	123	0	0	0	0	0	0
28-Apr	0	0	0	0	0	0	0
29-Apr	0	0	0	0	0	0	0
30-Apr	738	1	0	0	0	0	0
01-May	1081	1	0	0	0	0	0
02-May	0	0	0	0	0	0	0
03-May	17	0	0	0	0	0	0
04-May	75	1	0	0	0	0	0
05-May	98	0	0	0	0	0	0
06-May	2	0	0	0	0	0	0
07-May	298	2	0	0	0	0	0
08-May	1215	0	0	0	0	0	0
09-May	3054	0	0	0	0	0	0
10-May	780	0	0	0	0	0	0
11-May	3	0	0	0	0	0	0
12-May	58	0	0	0	0	0	0
13-May	2065	0	0	0	0	0	0
14-May	5825	1	0	0	0	0	0
15-May	2307	0	0	0	0	0	0
16-May	1485	0	0	0	0	0	0
17-May	541	1	0	0	0	0	0
18-May	0	0	0	0	0	0	0
19-May	742	0	0	0	0	0	0
20-May	10737	4	0	0	0	0	0
21-May	1791	2	0	0	0	0	0
22-May	540	0	0	0	0	0	0
23-May	720	0	0	0	1	0	0
24-May	0	0	0	0	0	0	0
25-May	30	3	0	0	0	0	0
26-May	50	3	0	0	10	0	0
27-May	747	16	0	0	14	0	0
28-May	6	4	0	0	40	0	0
29-May	66	5	0	0	7	0	0
30-May	10	3	0	0	34	0	0
31-May	289	20	0	0	27	0	0
01-Jun	43	1	0	0	14	0	0
02-Jun	0	0	0	0	50	0	0
03-Jun	0	0	0	0	100	0	0
04-Jun	0	0	0	0	150	0	0
05-Jun	5	0	0	0	176	0	0
06-Jun	13	0	0	2	240	0	0
07-Jun	3	4	0	0	395	0	0

- (continued) -

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Date	Emigrants		Immigrants		Immigrant Salmon		
	Dolly Varden	Steel-head	Dolly Varden	Steel-head	Sockeye Salmon	Coho Salmon	Pink Salmon
08-Jun	15	24	0	0	782	0	0
09-Jun	1	1	0	0	605	0	0
10-Jun	1	2	0	0	206	0	0
11-Jun	7	5	0	0	891	0	0
12-Jun	1	1	0	0	185	0	0
13-Jun	2	0	0	0	216	0	0
14-Jun	6	0	0	1	474	0	0
15-Jun	0	0	0	0	307	0	0
16-Jun	2	8	0	0	603	0	0
17-Jun	3	0	0	1	1013	0	0
18-Jun	2	1	0	0	210	0	0
19-Jun	1	0	0	0	9	0	0
20-Jun	2	51	0	0	221	0	0
21-Jun	2	0	0	0	500	0	0
22-Jun	1	0	0	0	232	0	0
23-Jun	0	0	0	0	168	0	0
24-Jun	0	0	3	0	404	0	0
25-Jun	0	0	2	0	480	0	0
26-Jun	0	0	5	0	400	0	0
27-Jun	0	0	8	0	306	0	0
28-Jun	2	0	0	0	340	0	0
29-Jun	0	0	9	0	343	0	0
30-Jun	0	0	11	0	263	0	0
01-Jul	0	0	24	0	403	0	0
02-Jul	0	0	76	0	284	0	3
03-Jul	0	0	50	0	154	0	3
04-Jul	0	0	69	0	174	0	4
05-Jul	0	0	48	0	187	0	3
06-Jul	0	0	0	0	82	0	0
07-Jul	0	0	149	0	154	0	23
08-Jul	0	0	231	0	222	0	9
09-Jul	0	0	755	0	425	0	31
10-Jul	0	0	610	0	185	0	19
11-Jul	0	0	12	0	84	0	0
12-Jul	0	0	703	0	51	0	18
13-Jul	0	0	952	0	191	0	14
14-Jul	0	0	300	0	30	0	2
15-Jul	0	0	685	0	614	0	10
16-Jul	0	0	605	0	255	0	62
17-Jul	0	0	652	0	110	0	91
18-Jul	0	0	840	0	218	0	110
19-Jul	0	0	1181	0	164	0	106
20-Jul	0	0	674	0	76	0	92

- (continued) -

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Date	Emigrants		Immigrants		Immigrant Salmon		
	Dolly Varden	Steel-head	Dolly Varden	Steel-head	Sockeye Salmon	Coho Salmon	Pink Salmon
21-Jul	0	0	1102	0	298	0	284
22-Jul	0	0	824	0	101	0	157
23-Jul	0	0	1003	0	270	0	342
24-Jul	0	0	1012	0	252	0	650
25-Jul	0	0	998	0	111	0	615
26-Jul	0	0	2180	0	119	0	1967
27-Jul	0	0	757	0	42	0	1639
28-Jul	0	0	1429	0	97	0	2896
29-Jul	0	0	2381	0	122	0	4019
30-Jul	0	0	1744	0	290	0	3287
31-Jul	0	0	1081	0	115	0	2790
01-Aug	0	0	1754	0	146	0	5000
02-Aug	0	0	450	0	49	1	3330
03-Aug	0	0	706	0	222	0	6797
04-Aug	0	0	278	0	23	0	4530
05-Aug	0	0	517	0	102	0	7280
06-Aug	0	0	486	1	72	0	9465
07-Aug	0	0	498	1	89	1	9280
08-Aug	0	0	515	1	125	4	8260
09-Aug	0	0	290	0	65	1	8860
10-Aug	0	0	130	0	43	3	7246
11-Aug	0	0	82	0	55	0	2204
12-Aug	0	0	85	0	72	4	4251
13-Aug	0	0	24	0	32	2	3000
14-Aug	0	0	87	0	49	4	3296
15-Aug	0	0	24	0	49	5	3332
16-Aug	0	0	47	0	144	10	5613
17-Aug	0	0	6	0	13	9	2895
18-Aug	0	0	41	0	28	27	12056
19-Aug	0	0	48	0	22	34	6374
20-Aug	0	0	8	0	7	28	2150
21-Aug	0	0	7	0	8	15	1400
22-Aug	0	0	1	0	6	11	1135
23-Aug	0	0	3	1	2	12	904
24-Aug	0	0	4	1	0	14	1454
25-Aug	0	0	28	1	26	125	4365
26-Aug	0	0	12	1	7	60	3089
27-Aug	0	0	8	0	3	11	825
28-Aug	0	0	3	1	23	12	563
29-Aug	0	0	1	1	1	36	565
30-Aug	0	0	1	1	8	49	969
31-Aug	0	0	1	0	1	41	1143
01-Sep	0	0	11	2	8	333	2124

- (continued) -

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Date	Emigrants		Immigrants		Immigrant Salmon		
	Dolly Varden	Steel-head	Dolly Varden	Steel-head	Sockeye Salmon	Coho Salmon	Pink Salmon
02-Sep	0	0	9	0	3	142	1883
03-Sep	0	0	0	0	0	50	295
04-Sep	0	0	1	0	0	21	100
05-Sep	0	0	2	1	1	105	290
06-Sep	0	0	9	2	0	63	342
07-Sep	0	0	8	2	1	67	700
08-Sep	0	0	7	2	0	67	398
09-Sep	0	0	40	6	10	900	837
10-Sep	0	0	20	1	0	55	115
11-Sep	0	0	18	1	1	88	241
12-Sep	0	0	14	0	0	350	155
13-Sep	0	0	27	2	0	551	61
14-Sep	0	0	19	0	0	350	52
15-Sep	0	0	17	2	1	780	38
16-Sep	0	0	35	4	0	335	34
17-Sep	0	0	38	3	1	845	80
18-Sep	0	0	44	3	1	680	57
19-Sep	0	0	88	3	0	1000	30
20-Sep	0	0	211	0	1	532	5
21-Sep	0	0	184	6	1	440	0
22-Sep	0	0	182	5	1	457	4
23-Sep	0	0	63	0	0	79	1
24-Sep	0	0	69	1	0	206	1
25-Sep	0	0	29	3	1	157	0
26-Sep	0	0	13	1	1	85	1
27-Sep	0	0	30	0	0	50	0
28-Sep	0	0	30	0	0	50	0
29-Sep	0	0	31	0	0	51	0
30-Sep	0	0	133	0	0	53	0
01-Oct	0	0	123	1	0	31	0
02-Oct	0	0	36	0	0	39	0
03-Oct	0	0	0	0	0	0	0
04-Oct	0	0	0	0	0	0	0
05-Oct	0	0	0	0	0	0	0
06-Oct	0	0	0	0	0	0	0
07-Oct	0	0	0	0	0	0	0
Total	35,605	165	30,851	65	17,820	9,531	158,721

APPENDIX B

Appendix B1. Data files used to produce this report

Q0030CA9.DTA - Buskin River creel survey angler count data.

Q0030IA9.DTA - Buskin River creel survey angler interview data.

Q0030LA9.DTA - Dolly Varden length sample taken from Buskin River sport harvest.

Q0030LB9.DTA - Buskin River weir emigration Dolly Varden tagging - new tag releases.

Q0030LC9.DTA - Buskin River weir emigration - Dolly Varden length samples and tag recaptures.

Q0030LD9.DTA - Buskin River population estimate, first event lengths and tag numbers.

Q0030LE9.DTA - Buskin River population estimate, second event lengths and tag numbers.

Q0030LG9.DTA - Buskin River Dolly Varden length samples, 12 July - 9 August 1989, plus additional lengths taken throughout the month of September.

Q0030LI9.DTA - Buskin River Dolly Varden length sample, 30 September 1989.

Q0030LK9.DTA - Buskin River Dolly Varden length at age, 1989 spring weir.

Q1140LA9.DTA - American River population estimate, first event lengths and tag numbers.

Q1140LB9.DTA - American River population estimate, second event lengths and tag numbers.

Q1630LA9.DTA - Olds River population estimate, first event lengths and tag numbers.

Q1630LB9.DTA - Olds River Population estimate, second event lengths and tag numbers.

Q0030BA9.DTA - Immigrant coho salmon length-at-age data.

These data files are all archived with Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518-1599. Contact Gail Heineman or Donna Buchholz (267-2369) for copies of the files and descriptions of the file formats.